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Long-Distance Interaction in Phonology

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by Gunnar Ólafur Hansson

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for Suzanne

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Preface

This book is a revised version of my 2001 doctoral dissertation from the University of California, Berkeley (Hansson 2001b). It represents the most extensive typological survey to date of long-distance consonant assimilation phenomena in the world's languages, referred to here under the traditional rubric of *consonant harmony*. The survey covers approximately 175 separate cases, drawn from more than 130 distinct languages and dialects.

Because of the challenges it poses for the fundamental question of locality in phonological interactions, consonant harmony provides a particularly intriguing research area for theoretical phonology and the phonetics-phonology interface. On the basis of several striking parallels between systematic assimilation patterns of this kind and on-line phonological speech errors (slips of the tongue), it is argued here that consonant harmony has its roots in the domain of speech planning, or phonological encoding for speech production. A generalized formal-generative analysis of consonant harmony is developed, couched in a modified version of the Agreement by Correspondence model (Rose & Walker 2000, 2004, Walker 2000a, 2000c, 2001). In that model, long-distance assimilation is understood as featural agreement operating over an abstract correspondence relation between a pair of highly similar co-occurring consonants. The modifications suggested here include the construal of such correspondence relations as directionally asymmetric (strictly anticipatory), and the formalization of the relevant agreement constraints as *targeted* constraints (Wilson 2000, 2001, 2003, 2006).

In the years since the appearance of my dissertation and the aforementioned works by Sharon Rose and Rachel Walker, a great deal of activity has taken place in this research area. Several new and interesting cases have come to light, such as coronal harmony in Kalasha (Arsenault & Kochetov 2008, 2009) and coronal harmony among Ndebele clicks (Sibanda 2004). Conversely, serious doubt has been cast on the interpretation of some previously iconic cases of consonant harmony, such as voicing harmony in Kera (Hansson 2004a, Pearce 2005, 2006, 2009). The growing attention paid to lexically gradient phonotactic generalizations (Frisch et al. 2004, Coetzee & Pater 2008) has led to the discovery of several cases of 'gradient consonant harmony', such as laryngeal harmony in Amharic (Rose & King 2007), coronal harmony in Komi-Permyak (Kochetov 2007), and dorsal and laryngeal harmony in

Gitksan (Brown 2008, Brown & Hansson 2008). Perhaps the most significant developments concern the transparent vs. opaque status of intervening segments. Sibilant harmony in Rwanda has been found to display opacity effects (Walker & Mpiranya 2005) and to be implemented in terms of gestural extension (i.e. 'spreading') at the articulatory level (Walker et al. 2008). This discovery, combined with a re-evaluation of sibilant voicing harmony in various Berber languages, and the opacity effects that it displays in the Imdlawn Tashlhiyt dialect (Elmedlaoui 1995 [1992]), shows that while exceedingly rare, segmental opacity effects are attested in consonant harmony and must be contended with. Parallel to these empirical advances, continued formal explorations have revealed that opacity effects are in fact fully compatible with the analysis of consonant harmony as long-distance agreement, and are predicted to occur by factorial typology (Hansson 2007a, 2007b; cf. also Hansson 2006a, Rhodes 2008, Walker 2009b on opacity in agreement-based analyses of vowel harmony systems).

In an attempt to reflect these recent advances, substantial revisions have been made to the original 2001 dissertation that forms the basis of this work. The bibliography has been expanded considerably, with about 180 additional entries, and these are cited throughout the book where appropriate. A sizeable number of cases have been added to the consonant harmony database underlying the typological survey, and the detailed overview in chapter 2 (especially §2.4) has been substantially revised to reflect these changes. In chapter 3, section §3.2.2 (on the transparency vs. opacity of intervening segments in consonant harmony) has been completely rewritten. On the other hand, the formal analysis portion of the work (chapters 4 and 5) has been allowed to stand relatively unchanged in terms of content (with the notable exception of the discussion of Bantu nasal consonant harmony in §4.3.3), as has the discussion of palatal-bias effects and other parallels with speech errors in chapter 6.

The decision to limit the substantial revisions largely to the more 'empirically' oriented chapters is motivated by the recognition that these are likely to remain relevant and useful far longer than the more 'analytical' chapters. Even if phonological theory undergoes some unforeseen dramatic shift with regard to its formal and conceptual underpinnings, the intriguing patterns and generalizations documented in chapters 2 and 3 (and 6) will surely continue to occupy future phonologists. Finally, the concluding summary in chapter 7 has been expanded so as to bring up issues pertaining to the diachronic emergence and 'phonologization' of consonant harmony, the relationship (diachronic and synchronic) of morpheme-internal co-occurrence restrictions to harmony processes that result in alternations, and the learnability challenges raised by long-distance phonotactic dependencies in general. These areas are likely to figure prominently in research on consonant harmony in the near future.

Gunnar Ólafur Hansson
Vancouver, Canada
July, 2009

Acknowledgements

This topic, and questions of long-distance phonological interactions and harmony processes in general, has been at the center of my research for more than a decade. I owe a tremendous debt of gratitude to a great number of people who during that period have, directly or indirectly, provided me with feedback (positive and critical alike), stimulating discussions, alternative perspectives, helpful suggestions of relevant data or literature, and moral and intellectual support in one way or another. I cannot possibly hope to enumerate all of these people here, though I will try my best to mention most of them here; I apologize in advance for any embarrassing omissions.

As this book is based on my dissertation, I would first like to extend my heartfelt thanks to the members of my supervisory committee, Sharon Inkelas, Andrew Garrett, Larry Hyman and Alan Timberlake. Alan raised provocative questions about synchrony vs. diachrony (a topic which has occupied me a great deal more since then), and Larry generously shared his insights and encyclopedic knowledge of the sound patterns of Bantu languages. Andrew, who will always be my inimitable role model as a scholar, went out of his way to give helpful advice and pointers to relevant literature, and has continued to do so over the years. My interest in this topic, and many ideas developed here, arose in part from Andrew's 1999 seminar on the diachronic evolution of harmony systems. Finally, I am particularly indebted to Sharon, my *Doktormutter*, whose support and professional guidance during my years at Berkeley (and beyond) did more than anything to prepare me for an academic career in linguistics. Sharon also graciously provided me a place to stay during the hectic final two weeks of dissertation writing, for which I will always be grateful.

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I had the good fortune to spend 2001–2003 as a faculty member in the Department of Linguistics at the University of Chicago, where my work in this area benefited from interactions with various people, including (to name but a few) Bill Darden, John Goldsmith, the late Kostas Kazazis, Jason Merchant, Salikoko Mufwene, Jerry Sadock, students Anne Pycha, Eduardo Ribeiro and other participants in a 2001 seminar on harmony systems. I am particularly grateful to the Chicago department for agreeing to defer my arrival there for a year. This allowed me to accept a Chancellor's Dissertation Year Fellowship from U.C. Berkeley, giving me the opportunity to delve deeper and further into this research project than would otherwise have been possible. Without the additional time that this provided, the present work would have ended up much more limited in scope.

The 2000–2001 academic year was largely spent in Vancouver and Prince George, British Columbia. The Linguistics department at the University of British Columbia provided a valuable (though unofficial) home away from home during that period, and later became my permanent academic domicile from 2003 onwards. During my years at UBC I have benefited tremendously from discussions with colleagues, occasional visitors and graduate and undergraduate students. Special thanks go to Doug Pulleyblank, with whom I have enjoyed a great many conversations (though not nearly enough!) about harmony, locality, features representations,, constraints, and all things phonological. Doug has been a wonderfully supportive colleague, mentor and friend, and provided motivational support during the final stages of this work for which I will always be grateful. Thanks also to Bryan Gick and Joe Stemberger, as well as to Jason Brown, Fusheini Hudu, Shane Jobber, Scott Mackie, Calisto Mudzingwa, Eric Rosen, Clinton Tsang and Noriko Yamane-Tanaka, as well as participants in a 2007 grad course on the phonetics-phonology interface (Joel Dunham, Jen Glougie, John Lyon, Mark Scott) and in a 2009 seminar on (non)locality in phonology (Heather Bliss, Raphael Girard, Beth Rogers, Murray Schellenberg, Anita Szakay, Carmela Toews).

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Various aspects of the research upon which this book draws have been presented at the HILP conference at Leiden University (1999), CLS at the University of Chicago (1999, 2001), the Athapaskan Language Conference in Moricetown (2000), the Contrast Conference at the University of Toronto (2002), BLS at U.C. Berkeley (2004), WCCFL at U.C. Davis (2004), the annual meeting of the CLA at the University of Manitoba (2004), the Workshop on Current Perspectives in Phonology at Indiana University (2006), the LSA annual meetings in Albuquerque (2006) and Chicago (2008), GLOW at the University of Tromsø (2007), the Phonology Fest symposium at Simon Fraser University (2008), and the Laboratory Phonology conference in Wellington, New Zealand (2008), in colloquia at the University of Chicago (2001), UBC (2001, 2002), Northwestern University (2002), the Franke Institute for the Humanities at the University of Chicago (2002), the University of Iceland (2004), the University of Calgary (2004), the University of Victoria (2004), Simon Fraser University (2005), the University of Alberta (2006), and in a course at the LSA Linguistic Institute at U.C. Berkeley (2009). I am grateful to audience members at all of these events for feedback and suggestions.

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1. INTRODUCTION

Harmony is the widespread phenomenon in the world's languages whereby all phonological segments of a particular type (e.g. all vowels, all obstruent consonants, all sibilant consonants) that occur within a particular domain—such as the word, the stem, or the morpheme—are required to *agree* with respect to some property. For example, all the vowels in a word may be required to be either front or back, or alveolar and postalveolar sibilants (i.e. sibilants vs. 'shibilants') may be prohibited from co-occurring within individual morphemes. Harmony is thus fundamentally a matter of *co-occurrence restrictions* on segments. The co-occurrence restriction may be asymmetric with respect to directionality (that is, the temporal order of the interacting segments); for example, a language might disallow rounded…unrounded vowel sequences while freely permitting unrounded…rounded sequences.

The standard view of harmony patterns is that they are a manifestation of *assimilation*. On this assumption, disharmonic sequences are absent because, should such a sequence arise, the phonological grammar of the language in question will 'repair' the offending sequence by altering the phonological properties of one segment so as to match those of the other. In other words, some property of one segment (the harmony *trigger*) is 'transmitted' to another segment (the harmony *target*). The nature of this interaction, and of the mechanism by which such 'transmission' takes place, is a major focus of the scholarly literature on harmony in theoretical phonology, the present work included.

Within morphemes, harmony manifests itself merely as a static phonotactic generalization, prohibiting disharmonic co-occurrences but allowing harmonic ones, as shown schematically in (1a). When the harmony domain extends beyond the confines of individual morphemes, harmony can be directly observed as an active process of assimilation. A potentially disharmonic combination is made harmonic by forcing one segment to agree with another in the phonological feature in question, as shown in (1b).

(1) Surface manifestations of harmony in phonological feature [±F]

a. Harmony within morphemes (static restriction):

Allowed	*Prohibited*
[+F]…[+F]	*[+F]…[–F]
[–F]…[–F]	*[–F]…[+F]

b. Harmony across morphemes (active process):

Input: /…[αF]…/ + /…[–αF]…/

↓

Output: …[αF]…[αF]… (or, alternatively: …[–αF]…[–αF]…)

The phenomenon of *vowel harmony*, where the interacting segments are vowels, is quite common cross-linguistically. It is well attested on all continents, in all major language families, and can be based on just about every phonological feature that has been used to cross-classify the vowel space: backness, rounding, height, tongue-root advancement or retraction, even rhoticity. Likewise, vowels and consonants are frequently required to agree with each other in properties such as nasalization or pharyngealization ('emphasis'). For example, nasality may spread from an underlyingly nasalized segment to nearby (nasalizable) vowels and consonants, as in Guaraní /ro-^{m}bo-porã/ → [r̃õmõpõr̃ã] 'I embellished you'. In the present work, phenomena of this kind (which are often discussed under the rubric of 'unbounded spreading') will be referred to as *vowel-consonant harmony*. The phonological properties and typological profile of vowel harmony and vowel-consonant harmony systems have been studied in great detail in the phonological literature (see, e.g., van der Hulst & van de Weijer 1995, Walker 2000b, Archangeli & Pulleyblank 2007).

Another possible manifestation of harmony is for consonants of a particular type to interact (i.e. required to agree in some property) across one or more intervening vowels—and possibly other types of consonants as well—where the intervening segments do not appear to participate in the harmony or be affected by the property being 'transmitted' from trigger to target. This phenomenon is known as *consonant harmony*, and is the focus of the present study. Because of its relative rarity in the world's languages, consonant harmony is not as well documented as other kinds of harmony. This in turn has stood in the way of developing a full understanding of the nature and characteristics of this phonological phenomenon.

Nevertheless, individual cases of consonant harmony have figured prominently in the literature on phonological theory over the past few decades, especially as regards the question of *locality* in phonological interactions. However, that discussion has tended to be based on a very small number of well known cases. Even the most ambitious survey-oriented studies to deal with consonant harmony systems, Shaw (1991) and Gafos (1999 [1996]), are relatively limited in their scope and the number of cases surveyed; the same is true of Odden (1994), which also deserves mention here, though it is not focused on consonant harmony in particular. The study in Hansson (2001b), which forms the basis of the present work, constitutes the most detailed typological investigation of consonant harmony phenomena in the world's languages to date, based on an extensive survey of attested cases in a wide range of languages (see also Rose & Walker 2004 for a similar typological overview, which partly draws on Hansson 2001b).

The size of the database that underlies this study (containing over 170 cases, drawn from about 130 separate languages or dialects) allows several important typological generalizations to emerge, which had eluded previous researchers in this area, and which strongly suggest that consonant harmony is fundamentally different from most cases of vowel harmony as well as vowel-consonant harmony. These empirical generalizations in turn form the basis of a formal phonological analysis of consonant harmony, couched in the constraint-based and output-oriented framework of Optimality Theory (OT; Prince and Smolensky 2004 [1993]; see also McCarthy 2002a, 2007) that is laid out in subsequent chapters. Finally, it is to be hoped that this investigation of consonant harmony in the phonological grammars of (adult) languages may shed some light on the relationship between such phenomena and the consonant harmony processes that are frequently observed in child language (Smith 1973, Ingram 1974, Vihman 1978, Stoel-Gammon & Stemberger 1994, Goad 1997, Bernhardt & Stemberger 1998, Berg & Schade 2000, Pater & Werle 2001, 2003).

1.1. Consonant Harmony: A Pre-Theoretical Definition

In a typological study of the kind undertaken here, it is important to adopt a careful working definition of the phenomenon about to be surveyed. The definition must be wide enough, as one must take care not to build in prior expectations or preconceptions, so as to avoid circularity. In the most extensive survey of consonant harmony to date (prior to Hansson 2001b), Gafos (1999 [1996]) appears to fall into this trap by building the very predictions of his theory of articulatory locality (see §1.2.3 below) into the definition of consonant harmony that guides his survey. As will be discussed below, an important corollary of the articulatory locality hypothesis is that consonant harmony should only be based on those articulatory parameters that control the shape and orientation of the tongue tip-blade. (This is because these alone are inherently capable of permeating intervening vowels and consonants without interfering significantly with the articulation or acoustic-perceptual characteristics of those intervening segments). These are, of course, precisely the parameters that define coronal-specific distinctions such as dental vs. alveolar vs. postalveolar, or apical vs. laminal; the prediction is thus that *coronal* harmony should be the only possible type of consonant harmony.

The survey in Gafos (1999) appears to confirm this prediction, but this is only because that survey is limited *a priori* to coronal harmony systems. No mention is made of long-distance consonant assimilations that do not involve such coronal-specific distinctions, many of which have been discussed in earlier literature (e.g. Odden 1994). The result is a circular argument, which seriously weakens Gafos' claim that the articulatory locality hypothesis is vindicated by the typology of consonant harmony systems. The hypothesis predicts that non-coronal consonant harmony should not exist, but any attested phenomena that might be taken as counterevidence against this prediction are systematically dismissed out of hand.

In order to avoid such circularity, this study will adopt the very simple and relatively theory-neutral working definition of consonant harmony stated in (2):

(2) Consonant Harmony (definition):

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

a. the two consonants can be separated by a string of segmental material consisting of at the very least a vowel; and

b. intervening segments, in particular vowels, are *not audibly affected* by the assimilating property.

The definition in (2) is also designed to be narrow enough to exclude phenomena that may well turn out to be fundamentally different in kind from consonant harmony. The (2a) restriction separates the (apparent) long-distance assimilations involved in consonant harmony from the assimilations under adjacency that are often found in consonant clusters (/ln/ → [lː], /sd/ → [zd]). It should be emphasized that the formulation in (2) does not necessarily encode an implicit assumption that long-distance assimilation and local assimilation are distinct phenomena, governed by entirely different principles. However, it is quite conceivable that the two differ significantly in some interesting ways. If that is the case, collapsing long-distance and local assimilation would likely muddle the picture and prevent clear generalizations about one or the other from becoming apparent.

The restriction in (2b), which limits the scope of the study to those assimilations where the intervening vowels and consonants are not *audibly* affected, separates consonant harmony from what was referred to above as vowel-consonant harmony, including such phenomena as nasal harmony (nasalization spreading) or pharyngealization harmony. Again, the restriction in (2b) does not in itself constitute an implicit assumption that these two phenomena are distinct—though that position will in fact be defended in this work. Indeed, several previous studies have made the claim that the two are essentially the same, and that intervening segments are affected by the 'spreading' property in consonant harmony as well, albeit without any readily audible result. The point in (2b) is that we must not take it for granted that this is the case. Consonant harmony may turn out to be different from vowel-consonant harmony in some fundamental respect, but such differences will only emerge if consonant harmony is examined from the perspective that it is potentially unique.

Finally, another limitation that is built into (2) deserves mention.[1] This study equates harmony with assimilatory interactions; all cases involving long-distance *dissimilation* between consonants thus fall outside its scope. In this respect the present work differs from many earlier studies, such as those by Shaw (1991) and Odden (1994). Again, it may well

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[1] As regards the inclusion of 'static' co-occurrence restrictions (morpheme structure constraints) alongside 'active' assimilatory processes (alternations), see §2.3 for justification.

turn out that consonant assimilation and dissimilation are governed by the same principles and constrained in similar ways. But this cannot be assumed *a priori*, and the inclusion of dissimilation cases would have necessitated raising many additional questions beyond those examined here. For example, laterals and rhotics ([l] vs. [r]) can interact in long-distance assimilation (harmony) as well as in long-distance dissimilation, but the latter appears to be far more common cross-linguistically. Conversely, contrasting sibilant fricatives like [s] vs. [ʃ] are the consonant type which is by far the most often implicated in long-distance assimilations, whereas extremely few cases of sibilant *dissimilation* are attested (e.g. /s…s/ → [ʃ…s]). The explanation for such striking asymmetries is an interesting and important issue in itself, but by excluding dissimilations from the present study, this is left to future investigations.

There is one area where the line between dissimilation and assimilation is often difficult to draw in practice, namely in static co-occurrence restrictions, which govern the permissible shapes of morphemes (typically roots) in many languages; hence the conventional term *morpheme structure constraint* (MSC). In such cases, the evidence available tells us that certain combination of consonants are disallowed, but we frequently have no way of telling how a (hypothetical) input form with the disallowed combination would be 'repaired' in the output: by assimilation or by dissimilation. Imagine a language where the sibilants [s] and [ʃ] are not allowed to co-occur within a morphemes: [s…s] and [ʃ…ʃ] is allowed but *[s…ʃ] and *[ʃ…s] are not. We might account for this by assuming that the language has consonant harmony, and that hypothetical inputs like /s…ʃ/ or /ʃ…s/ would undergo assimilation to [ʃ…ʃ] or [s…s] (thus merging with the faithful outputs of underlying /ʃ…ʃ/ or /s…s/). But it is equally possible—though perhaps less plausible in this case—that the favored 'repair' is instead dissimilation. For example, the grammar might force hypothetical inputs like /s…ʃ/ and /ʃ…s/ to dissimilate to [t…ʃ] and [ʃ…t].

In the scenario just outlined, the dissimilation alternative may seem rather far-fetched. But the truth is that certain cases that might conceivably be analyzed as (morpheme-internal) consonant harmony have been interpreted in precisely this way. In a number of languages, multiple ejective stops are not allowed to co-occur in morphemes unless they are completely identical (that is, share the same place of articulation). Thus morphemes like /t'aka/ and /t'at'a/ are allowed, but not */t'ak'a/. One way of stating this generalization is that if co-occurring stops differ in [Place], they must not both be specified as [+constricted glottis]. This characterization is equivalent to saying that a hypothetical input like /t'ak'a/ would surface as [t'aka] (or perhaps [tak'a]) in the output, by *dissimilation* in terms of [±constricted glottis]. That is exactly how co-occurrence restrictions of this type are treated in the OT analysis developed by MacEachern (1999). However, we could equally well paraphrase the generalization as follows: 'if two co-occurring stops are both [+constricted glottis], then they must also agree in [Place]'. This, then, would be equivalent to saying that an input like /t'ak'a/ gets repaired by 'place harmony'—that is, by *assimilation* to [t'at'a] or [k'ak'a]—rather than by 'laryngeal dissimilation' to [t'aka] or [tak'a].[2]

Before proceeding to discuss previous approaches to the phonological analysis of consonant harmony, it is useful to look at a straightforward case that fits the definition in (2) above. In the Athapaskan language Navajo, consonant harmony affects two sibilant classes: [+anterior] /s, z, ts, ts', dz/ and [–anterior] /ʃ, ʒ, tʃ, tʃ', dʒ/. Members of these two classes cannot co-occur morpheme-internally (a restriction which dates at least as far back as Proto-Athapaskan-Eyak; Krauss 1964). When sibilants from different classes are juxtaposed by morpheme concatenation, harmony is enforced by means of anticipatory (regressive) assimilation: the rightmost sibilant determines the [±anterior] value of any preceding sibilants.

(3) Navajo: sibilant harmony in 1SgPoss /ʃi-/ (Sapir & Hoijer 1967)

	a.	ʃi-łí̃ːʔ	'my horse'
		ʃi-taːʔ	'my father'
	b.	ʃí-tʃí̃ːh	'my nose'
	c.	si-ts'aːʔ	'my basket'
		si-zid	'my scar'

The forms in (3a), where the noun stem contains no sibilant, reveal that the underlying form of the 1Sg possessive prefix is /ʃi-/. It surfaces as such also when the stem contains a sibilant of the [–anterior] class (3b). However, if a [+anterior] sibilant occurs in the stem, the /ʃ/ of the prefix assimilates to it, surfacing instead as [si-] (3c).

The examples in (3) involve a sibilant in a prefix harmonizing with one in the following root morpheme, but the harmony trigger may just as well belong to an affix morpheme. Moreover, the harmony is not sensitive to the number of sibilants in the word; the underlying [±anterior] specification of the rightmost one determines the surface [±anterior] value of all preceding sibilants, as shown in (4).

(4) Navajo: interaction of roots, perfective /s-/ and '4th person' /dʒi-/

	a.	/dʒi-di-báːh/	dʒidibáːh	'he (4th p.) starts off to war'
	b.	/dʒi-s-tí̃/	dziztí̃	'he (4th p.) is lying'
	c.	/dʒi-s-ɣiːʃ/	dʒiʒɣiʃ	'he (4th p.) is stooped over'

The so-called '4th person' (or deictic subject) prefix has the underlying form /dʒi-/, as is evident from (4a), where no sibilant follows. When followed by the perfective prefix /s-/ (which gets voiced to [z-] under conditions not relevant here), this prefix surfaces instead as [dzi-] due to sibilant harmony (4b). However, when this very same prefix sequence /dʒi-s-/ is fol-

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[2] Notice that this is entirely parallel to the s/ʃ case discussed above, where the choice was between 'anteriority harmony' (/s…ʃ/ → [ʃ…ʃ]) and 'stricture dissimilation' (/s…ʃ/ → [t…ʃ]).

lowed by a stem containing a sibilant, as in (4c), it is the stem sibilant that determines the [±anterior] value of both prefix sibilants.

Before leaving this example, a few characteristics deserve to be pointed out which will become relevant in the following chapters. First of all, the directionality of assimilation is anticipatory (regressive, right-to-left), a property which is highly characteristic of consonant harmony systems. Secondly, the harmony is neutralizing and feature-changing, in the sense that the (prefix) sibilants targeted by the harmony are underlyingly specified as either [+anterior] or [–anterior] depending on the morpheme involved. This underlying contrast is obliterated by harmony, by means of a change (a violation of input-output faithfulness) of either [–ant] → [+ant] or [+ant] → [–ant] depending on the circumstances (that is, whether the underlying sequence is [–ant]…[+ant] or [+ant]…[–ant]). This, again, is not an uncommon state of affairs in consonant harmony systems, but is quite rare for vowel harmony.[3] Finally, the harmony is oblivious to any vowels and nonsibilant consonants that may intervene between the trigger and target sibilants. In (4c), the intervening [ɣ] has no effect on the application of harmony, nor is it audibly affected by the [–anterior] property being transmitted from one sibilant to another. The same is true of non-sibilant coronals like [t] or [n], as in /dʒi-s-téːʒ/ → [dʒiʒtéːʒ] 'they two (4th p.) are lying'. As will be discussed at length below, the complete inertness, or *transparency*, of intervening segments is a characteristic property of consonant harmony. By contrast, vowel harmony and vowel-consonant harmony processes very often display segmental *opacity* effects, whereby intervening segments of a particular class block the propagation of harmony.

1.2. Previous Research on Consonant Harmony

This section briefly summarizes the coverage of consonant harmony phenomena in earlier literature, focusing in particular on the analysis of long-distance consonant assimilations within generative phonology. Particularly important in this respect are analyses that rely on the notion of *spreading* (of phonological features and/or articulatory gestures). One of the major claims of this work (see also Walker 2000a, 2000c, 2001, Rose & Walker 2004) is that the phonological constraints that motivate consonant harmony do not to call for feature spreading but rather featural *agreement* between segments belonging to some designated class.

1.2.1. Early Sources

It appears that the first to explicitly discuss phenomena that fall under the definition of consonant harmony was the Danish linguist Otto Jespersen. In his textbook on phonetics, he discusses various examples of non-local assimilation, both between vowels and between conso-

[3] For further discussion of this point, and a possible explanation based on learnability factors and diachronic language change, see Hansson (2008b).

nants (Jespersen 1904:170-71). Jespersen argues that cases of assimilation at a distance (*Assimilation auf Abstand*) are often most appropriately characterized as 'harmonization' (*Harmonisierung*). He then goes on to list a considerable number of examples of such harmonization, all of which seem to involve sporadic (i.e. not regular) historical sound changes. The issue is also taken up in Jespersen (1922:279-80), where a partially overlapping list of examples is presented. Some of Jespersen's examples of 'consonant harmonization' (*Konsonanten-Harmonisierung*) can be classified as sibilant harmony, including the 'vulgar' Danish and German pronunciation [ʃeʁˈʃɑnt] or [ʃeʁˈʒɑnt] for *Sergeant* ([seʁˈʃɑnt]) and French *chercher* < *cercher* (cf. English *search*) from Lat. *circare*. All of these involve anticipatory [–anterior] assimilation between sibilants: [s…ʃ] > [ʃ…ʃ] or [s…ʒ] > [ʃ…ʒ]. Interestingly, several of the other examples Jespersen cites appear to be classifiable as major-place harmony involving labiality, specifically changes of a coronal to a labial under the influence of a nearby labial (e.g. [labial]…[coronal] > [labial]…[labial]): English *brimstone* < *brinstone*, *megrim* < *migraine*, as well as English *pilgrim* and German *Pfriem* from Italian *pellegrino*.

It is clear from the discussion surrounding these examples that Jespersen considers consonant harmonization to be completely equivalent to the 'vowel harmonization' (*Vokal-Harmonisierung*) that is observed in other sporadic changes such as Italian *Braganza* < *Brigantia*, *uguale* < *eguale*, *maraviglia* < *miraviglia*, French *camarade* < *camerade*, and the common French pronunciations [ɔ̠ʒɔ̠ʁˈdɥi] for *aujourd'hui* ([ɔ̠ʒu̠ʁˈdɥi]), idiolectal [sɔ̠lɔ̠ˈnɛl] for *solennel* ([sɔ̠lə̠ˈnɛl]), [rɛ̠ˈzɛ̠rv] for *réserve* ([re̠ˈzɛ̠rv]), [ø̠rø̠peˈɛ̃] for *européen* ([ø̠rɔ̠peˈɛ̃]), and so forth. It is worth noting that Jespersen evidently considers such sporadic vowel assimilations to be the diachronic source of the kinds of systematic co-occurrence restrictions that the term 'vowel harmony' is nowadays reserved for: '[i]n Ugro-Finnic and Turkish this harmony of vowels has been raised to a principle pervading the whole structure of the language' (Jespersen 1922: 280).

In light of what will be proposed in the present work regarding the roots of consonant harmony phenomena in the domain of speech planning (see esp. chapter 6 below), it is especially interesting to note that Jespersen clearly takes consonant harmonization—and perhaps vowel harmonization as well—to originate in phonological speech errors (slips of the tongue):

> Each word is a succession of sounds, and for each of these a complicated set of orders has to be issued from the brain and to the various speech organs. Sometimes these get mixed up, and a command is sent down to one organ a moment too early or too late. The inclination to make mistakes naturally increases with the number of identical or similar sounds in close proximity. This is well known from those 'jaw-breaking' tongue-tests with which people amuse themselves in all countries […] (Jespersen 1922:279–280)

He goes on to mention the well-known English tongue twister *She sells seashells by the seashore* in this context, and explicitly considers the sporadic historical change observed in French *chercher* < *cercher* (see above) to be equivalent to 'when we lapse into *she shells* instead of *sea shells* or *she sells*' (ibid.).

The exact same connection to speech errors is made by the ethnographer-linguist John Peabody Harrington in his posthumously published study of sibilant harmony in the Chumashan language Ventureño (Harrington 1974; the study was written in the 1920s on the basis of data gathered in 1916). Unlike Jespersen, Harrington is here discussing a full-fledged consonant harmony system, rather than sporadic and isolated historical changes, but he cites the very same English tongue twister as a direct parallel:

> Reasons for this harmony are not difficult to discern. Everyone knows how hard it is to make the rapidly alternating adjustments in a sentence such as “she sells seashells” and how awkward the changing sibilants sound in such a sequence. It might therefore be expected that in a language full of sibilants of dull and sharp varieties some means would be devised for simplifying this alternation. (Harrington 1974:5)

Both Jespersen and Harrington thus express the same general idea: that consonant harmony has its roots in the domain of articulatory planning, and that it is in some sense parallel to the interference effects that are observed in the production of difficult tongue-twisters (and presumably in phonological speech errors in general).

Broadly speaking, this is essentially the same understanding of consonant harmony as will be argued for in this work. One should be careful, however, not to read too much significance into the fact that these linguists of the early 20th century appeal to articulatory planning to explain consonant harmony phenomena. This may well be partly due to the hegemony of articulatory over acoustic-auditory-perceptual considerations in phonetics at the time of Jespersen’s and Harrington’s writings. Nevertheless, it cannot be denied that the correspondence between the ideas expressed by these scholars and the conclusions arrived at in the present study is striking.

Though Jespersen spoke of ‘consonant harmonization’ (*Konsonanten-Harmonisierung*) in discussing sporadic sound changes, the currently conventional term ‘consonant harmony’ appears to have been first proposed by Karl V. Teeter in a short article on Wiyot and Cree (Teeter 1959). Teeter briefly mentions phenomena in a number Native American languages—Wiyot, Cree, Navajo and Wishram—which have to do either with consonant harmony (in the sense defined in §1.1 above) or sound symbolism, or a combination of both. The distinction between consonant *harmony* on the one hand—which by definition involves assimilation—and consonant *symbolism* on the other, is somewhat muddled, in part owing to the brevity of the article. However, Teeter does explicitly note that Navajo sibilant harmony is ‘purely morphophonemic’, in that it is phonologically rather than morphologically or semantically conditioned. In the other languages Teeter cites, by contrast, the alleged consonant harmony coexists with—and largely overlaps, in terms of its effects—elaborate systems of diminutive-augmentative sound symbolism. In Wiyot, for example, the coronals /t, s, l/ are replaced with [tʃ, ʃ, r] in augmentative forms (which also add the suffix /-atʃk/) and with [ts, ʃ, r] in diminutive forms (which take the suffix /-oːts/).

As Teeter notes, Wiyot also shows these very same alternations in contexts that more closely resemble consonant harmony, in that the conditioning environment is phonologically defined. When a stem contains a consonant of the ‘diminutive’ or ‘augmentative’ type—that is, a /ts/, /tʃ/, /ʃ/ or /r/—affixes with /t, s, l/ will change accordingly.[4] Thus, for example, a suffixal /s/ is realized as [ʃ] after a stem that contains /ʃ/, and a suffixal /l/ is realized as [r] after a stem containing /r/. As instances of consonant harmony, neither of these processes is particularly remarkable; sibilant harmony and liquid harmony is attested elsewhere (see §2.4.1.1 and §2.4.5, respectively). The problem is that in the Wiyot case, the two are collapsed into a single system: /s/ → [ʃ] also takes place after stems with /r/, and /l/ → [r] is likewise triggered by stems with /ʃ/. While it is conceivable that the Wiyot segments that are represented here as /ʃ, r/ share some crucial articulatory and/or acoustic properties (e.g. apicality), the ‘cross-over’ between sibilant and liquid assimilations makes it rather less feasible to analyze this case as long-distance consonant assimilation (though see Cole 1991 for an attempt along those lines).

For this and other related reasons, Gafos (1999) rejects the idea that cases like Wiyot, where sound symbolism is (partly) involved, should be considered examples of consonant harmony: ‘[h]owever systematic or interesting these phenomena may be, they cannot be coherently analyzed as instances of assimilation’ (Gafos 1999: 231). While this is true of most reported cases of sound symbolism, the possibility should not be ruled out that sound symbolism phenomena might be implicated in the *diachronic* emergence of certain individual consonant harmony systems. The pervasive superficial identity (or ‘agreement’) patterns that are often a by-product of sound symbolism might undergo analogical reanalysis, with language learners misinterpreting them as *bona fide* instances of assimilation—and hence consonant harmony—rather than as global alternations in phonological shape conditioned by morpho-semantic factors (for further discussion, see §6.3.3 below).

1.2.2. Consonant Harmony in Generative Phonology

It is safe to say that harmony phenomena have played a very prominent role in the development of generative phonological theory over the past several decades. The discussion has tended to focus on vowel harmony rather than consonant harmony, which is hardly surprising given the fact that the former is vastly better represented in the world’s languages than the latter. Perhaps because of this ‘primacy’ of vowel harmony, theoretical phonologists who have worked on issues pertaining to harmony systems have consistently assumed that what-

[4] Teeter notes a similar phenomenon in Cree, where /t/ → [ts] in the formation of diminutives (with addition of a suffix that contains /s/), but where that same change is ‘carried over also to some non-diminutive forms with an /s/ near the end of the word’ (Hockett 1956:204). In the latter cases, which seem to be due to a kind of surface analogy, the morpho-semantic conditioning is absent and the /t…s/ → [ts…s] change seems to be more akin to consonant harmony than sound symbolism.

ever (synchronic) mechanism or motivation underlies vowel harmony (as well as vowel-consonant harmony) is also responsible for consonant harmony. This was trivially true in the classical generative phonology of the 1960s and 1970s, in which all processes of segmental phonology, including assimilation and thereby harmony as well, were expressed using essentially the same notational scheme of feature-based rewrite rules. But the intuitive idea that consonant harmony and vowel harmony are merely different manifestations of the same basic phenomenon—an *a priori* assumption which has simply been taken for granted rather than justified with explicit argumentation—has proven very long-lived, and has survived all major theoretical shifts that have occurred in the development of generative phonology over the past several decades.

Halle & Vergnaud (1981) develop a generative analysis of harmony which in part makes use of the formal constructs of metrical phonology (see also Poser 1982). Halle & Vergnaud distinguish between two classes of harmony systems. The first is what they call *dominant* harmony; this is exemplified not only by systems traditionally referred to as dominant-recessive (e.g. Kalenjin tongue-root harmony) but also many others, such as Akan tongue-root harmony, Finnish backness harmony, and Capanahua nasal harmony. These phenomena are analyzed by Halle & Vergnaud as involving autosegmental feature spreading, such that the 'dominant' feature value (e.g. [+ATR]) spreads from trigger to target. This results in a feature-sharing configuration, where a single featural autosegment (the spreading feature) is simultaneously associated with two or more segmental anchors.

The other class Halle & Vergnaud (1981) recognize is what they refer to as *directional* harmony, which they exemplify with rounding harmony in Turkish and Halh (Khalkha) Mongolian, as well as sibilant harmony in Navajo.[5] For directional harmony, Halle & Vergnaud suggest that 'languages make use of a mechanism […] which is an adaptation of the metrical structure mechanism that is otherwise employed in various stress and accent systems' (1981:10). Under this view, harmony results from feature percolation by way of a branching metrical-tree structure erected over the participating segments. Such trees are either uniquely right-branching, yielding consistent right-to-left (regressive, anticipatory) harmony, as in Navajo, or uniquely left-branching, yielding left-to-right (progressive, perseveratory) harmony, as in Turkish or Mongolian.

In Halle & Vergnaud's metrical analysis, the feature specification of the designated terminal element (or 'head') of the tree—that is, the segment which is dominated exclusively by strong (head) nodes rather than weak (non-head) nodes—is copied onto the root of the tree, and percolates downward from there to all terminal nodes of the tree. This is illustrated schematically in (5) for Navajo sibilant harmony. A right-branching tree is erected over any and all coronal sibilants in the word, indicated here with 'S'. The underlying [±anterior] specifications of the individual sibilants are given as [αanterior], [βanterior], and so on.

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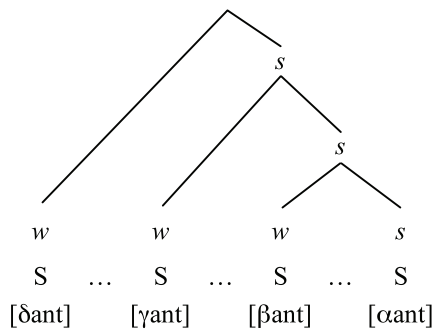
[5] Interestingly, Halle & Vergnaud (1981) also analyze voicing assimilation in Russian consonant clusters as a case of 'directional harmony'.

(5) Metrical analysis of right-to-left sibilant harmony (Halle & Vergnaud 1981)



The [αanterior] specification of the rightmost sibilant (i.e. the 'designated terminal element') is copied by rule onto the root of the tree, from whence it percolates down to each and every terminal node—that is, to each preceding sibilant—overriding the underlying feature specifications ([βanterior], [γanterior], etc.) of the segments in question.

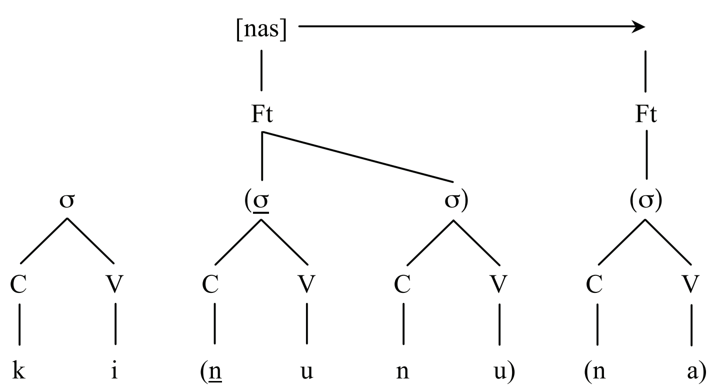
Though the metrical formalism of Halle & Vergnaud (1981) did not become widely accepted as an appropriate tool for analyzing harmony phenomena, it has certain interesting properties. For example, those segments that are not terminal nodes in the tree—in the case of sibilant harmony, these would be vowels and non-sibilant consonants (including other coronals)—are irrelevant to the harmony and cannot by definition interfere with or block the propagation of the harmonic feature from one terminal node (sibilant) to another.

The approach to harmony developed by Piggott (1996; see also Piggott 1997, 2003) shares certain affinities with Halle & Vergnaud's metrical analysis. Piggott's analysis, which focuses primarily on nasal harmony, relies on the notion of *prosodic licensing*, and takes the view that harmony may hold as a relation either between segments or between suprasegmental units (syllables, feet). For Piggott (1996), harmony is driven by a family of constraints on featural agreement between adjacent constituents which he calls CONSTITUENT CONCORD (CONCORD). The constituent that licenses the harmonic feature may be specified parametrically as either the segment, the syllable or the foot. The directionality is also a matter of parametric variation, with CONCORD-R driving left-to-right harmony and CONCORD-L right-to-left harmony. Piggott (1996) uses this formalism to analyze both nasalization spreading in languages like Malay and Barasano and the long-distance nasal consonant harmony found in various Bantu languages (see §2.4.4 below). The latter is analyzed as harmony at the level of either the syllable (Lamba) or the foot (Kongo). The fact that intervening vowels are not realized as nasalized is attributed to Structure Preservation (Kiparsky 1985); intervening obstruents are likewise unaffected because only sonorant consonants can bear nasality in the languages in question.

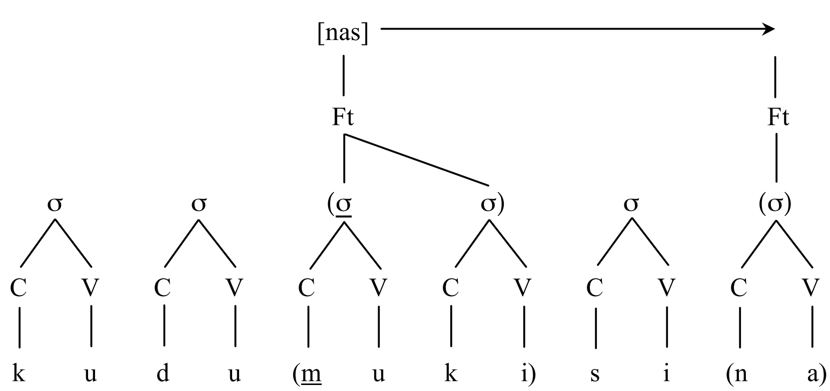
The similarity to the metrical-tree analysis lies in the fact that harmony is propagated by way of higher-order nodes in a suprasegmental tree structure. Furthermore, just as the metrical harmony trees of Halle & Vergnaud (1981) are *ad hoc* structures that serve no other purpose than to account for harmony, the same goes for the suprasegmental 'foot' constituent that Piggott (1996) employs to account for unbounded nasal consonant harmony in Kongo. The examples in (6) illustrate how this case is captured in Piggott's analysis; in both cases an /l/ in a suffix surfaces as [n], harmonizing with a nasal in the preceding verb stem.

(6) Kongo: nasal consonant harmony as 'foot-level' harmony (Piggott 1996)

a. /-kin-ulul-a/ → [-kinununa] 're-plant'



b. /ku-dumuk-is-il-a/ → [kudumukisina] 'to cause to jump for'



As should be apparent from the structures in (6), the 'feet' that license the [nasal] feature, and between which nasal harmony is assumed to hold, are *not* the independently motivated prosodic constituents that ordinarily govern stress patterns, word minimality effects, or truncation and reduplication patterns in various languages. Instead, these are a special type of constituent whose existence is assumed solely for the purpose of accounting for harmony: '[t]he foot that plays a role in harmony is an autonomous unit called the Harmony Foot (H-Foot)' (Piggott 1996:158). A Harmony Foot is projected from any segment that bears the harmony feature [nasal] in the underlying representation, and this segment is associated with the head syllable of that foot. This is indicated by underlining in the diagrams in (6). A Harmony Foot is maximally binary, and in Kongo it is assumed to be left-headed ('trochaic').

In (6a), the disyllabic H-Foot encompasses the second and third syllables, and any and all potentially nasal-bearing segments within that constituent surface as nasal; hence /…lu…/ → […nu…] in the non-head syllable of the H-Foot. In the disyllabic foot of (6b), on the other hand, the non-head syllable /ki/ contains no nasalizable segment and therefore surfaces intact. As for the final syllable in each of (6a) and (6b), it gets parsed into a (degenerate) H-Foot, to which the [nasal] feature is associated due to the special constraint CONCORD-R; this assimilatory relation is indicated by the arrow connecting the two H-Foot constituents. The reason why the penultimate syllable [si] in (6b) is 'skipped' is that it contains no potentially nasal-bearing segment. Such a syllable could only be parsed into the dependent position of a (trochaic) H-Foot, as the preceding syllable [ki] is; since a H-Foot is maximally binary (disyllabic), the [si] syllable must remain unparsed.

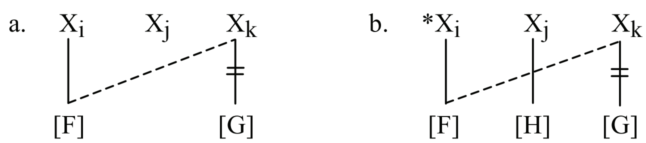
It should be emphasized that this licensing-based analysis equates consonant harmony (as defined in §1.1) with vowel harmony and vowel-consonant harmony, in that these phenomena are all taken to be manifestations of the same basic types of phonological relations and operations. Piggott (1996) applies his analysis not only to nasal consonant harmony but also to nasal harmony (nasalization spreading). Moreover, he explicitly suggests that transparency effects in certain vowel harmony systems (Wolof tongue-root harmony, Mongolian rounding harmony) indicate that in the languages in question the harmony operates between H-Foot constituents rather than between syllables. In such systems, syllables that contain a transparent vowel 'are either assigned to the dependent position in H-Feet or remain unfooted' (Piggott 1996:171), just as in syllables without nasal-bearing segments in Kongo.[6]

Although they allow for interesting possibilities, the full implications of which have not been fully explored, analyses of harmony phenomena in terms of metrical trees, 'harmony feet' or other higher-order constituents, have never entered the mainstream of generative phonological theory. By far the most common mechanism used to account for harmony (consonant harmony included) is autosegmental feature spreading. The basic aspects of this kind of analysis should be familiar enough that they do not need to be explained in detail (see, e.g.,

[6] Piggott (1996:170) concludes that his model 'seems to allow for the occurrence of other cases of long-distance consonant agreement', but refrains from taking a definitive position on 'what is responsible for restrictions on consonant harmony'. Nevertheless, he makes the interesting speculation that any feature that may be licensed by a higher prosodic category, such as the H-Foot, must be compatible (in principle) with *vowels*. This is because feet are headed by syllables, which are in turn headed by vowels. From this Piggott draws the conclusion that '[c]onsequently, syllable and foot harmonies may be restricted to those patterns in which harmonic features can be organized as vowel features.' Interestingly, this would completely rule out the possibility of coronal harmony (e.g. sibilant harmony), which is the most common type of long-distance consonant agreement by far; Piggott does not appear to be aware of this problematic prediction.

Clements 1980, Clements & Sezer 1982, Steriade 1986, Archangeli & Pulleyblank 1989, 1994, Shaw 1991, Odden 1994, Clements & Hume 1995). A schematic illustration of harmony as autosegmental spreading is given in (7).

(7) Harmony as autosegmental spreading:



The elements X_i, X_j, X_k can either be construed as representing segments (i.e. root nodes) or as hierarchical nodes located lower in the feature-geometric tree. For example, they might stand for class nodes like [Laryngeal] or [Place], or articulator nodes (major-place features) such as [Coronal] or [Dorsal]. Likewise, the elements that are here labelled [F], [G], [H] represent either individual features (terminal nodes, such as [(+)nasal], [–anterior] or [–high]) or superordinate feature-geometric nodes such as [Laryngeal] or [Coronal]. In the scenario in (7a), X_i triggers harmony in the following X_k by way of node [F] spreading from the former to the latter.[7] The intervening element X_j has no effect on this interaction in (7a), since it carries no specification on the tier where [F] and [G] reside. In (7b), however, where X_j is specified (as [H]) on that same tier, it has the effect of *blocking* the harmony, since spreading of [F] from X_i to X_k would result in a line-crossing violation.

The question of *locality* is thus an extremely important issue in all spreading-based analyses of harmony. Let us assume, for (7a), that it is indeed the case that segments intervening between trigger and target (X_j) are genuinely transparent—that is, that they do not show evidence of carrying the feature [F] in the output representation. In order for the long-distance assimilation in (7a) to be possible, the class of *target* elements must first be appropriately defined, such that segments of the X_j type are not targeted: [F] should spread to X_k, not to both X_j and X_k. Secondly, any and all intervening segments that are *transparent* to the harmony must be unspecified on the relevant tier, since otherwise harmony will be blocked as in (7b). Given these assumptions, harmony can be construed as a local relation, in that the interacting segments are *adjacent* on the relevant autosegmental tier (the one hosting [F], [G], [H]). This locality or adjacency requirement has been expressed in slightly different ways in different works (see, e.g., Steriade 1986, Archangeli & Pulleyblank 1987, 1994, Shaw 1991, Odden 1994), though all are variations on a common theme. Two representative example definitions are quoted in (8).

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[7] In the diagram in (7a), X_k is shown as having its own feature specification ([G]) on the relevant tier, which gets eliminated (delinked) as part of the spreading process. This is by no means necessary; the harmony in question might just as well be a 'feature-filling' operation, if target elements (X_k) can be assumed to lack specifications on the [F]/[G]/[H] tier.

(8) Conditions on locality in phonological interactions

a. Strict Adjacency (Shaw 1991)
The target of a phonological operation must be adjacent to the trigger on the relevant autosegmental tier.

b. Locality Condition (Odden 1994)[8]
In a relation involving A, B and the nodes α, β which they immediately dominate, nothing may separate α and β unless it is on a distinct plane from that of α and β.

Nowhere are the issues of locality and adjacency raised more acutely than in consonant harmony processes, where the trigger and target consonants are often separated by long stretches of intervening segmental material, all of which appears to be unaffected by the 'spreading' feature. Following the adjacency conditions expressed in (8), the fact that these intervening segments are *transparent* to the harmony indicates that they are not specified on the autosegmental tier (and/or plane) on which the harmony is operating. To ensure this—or, to put it differently, to explain why and how transparent segments are able to be transparent—autosegmental analyses of consonant harmony have typically relied quite heavily on representational devices provided by *feature geometry* and/or *underspecification*.

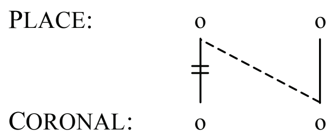
Shaw's (1991) analysis of coronal harmony in Tahltan is a good example of this general approach. Tahltan has a three-way harmony system involving the fricatives and affricates of the following sets: dental /θ, ð, tθ, tθ', dð/, alveolar /s, z, ts, ts', dz/ and postalveolar /ʃ, ʒ, tʃ, tʃ', dʒ/. Within a word, the rightmost coronal belonging to any of these three series triggers harmony on any and all preceding coronals that are likewise members of any of the series. Non-coronal consonants, as well as all vowels, are transparent to this harmony. More importantly, so are the plain coronal series /t, t', d, n/, as well as the lateral series /ɬ, l, tɬ, tɬ', dl/, as can be seen from such examples as /ja-s̲-tɬ'ɛt̲ʃ̲/ → [jaʃtɬ'ɛt̲ʃ̲] 'I splashed it' or /ni-θ̲i(d)-t'aːt̲s̲/ → [nis̲it'aːt̲s̲] 'we got up' (interacting coronals have been underlined in these forms).

Shaw (1991) analyzes Tahltan coronal harmony as resulting from the simple rule formulated in (9). By this rule, the rightmost [Coronal] node spreads leftward to any preceding segments that are specified as [Coronal], with concomitant delinking of the pre-existing [Cor-

[8] Odden (1994) further assumes that additional adjacency conditions may be imposed on individual phonological rules, such as Syllable Adjacency (target and trigger must be in adjacent syllables) or Root Adjacency (the root nodes of target and trigger must be adjacent). Another such language-specific condition is Transplanar Locality (nothing that separates the nodes dominating target and trigger may also dominate an element on the target tier), which effectively collapses planar distinctions. For example, Transplanar Locality allows for the possibility that intervening labial consonants might block rounding harmony (in some languages) on the assumption that rounding harmony spreads [labial] between V-Place nodes (whereas labial consonants have [labial] directly under C-Place; Clements & Hume 1995).

onal] node of the target consonant. In other words, this is essentially a mirror image of what we saw in (7a).

(9) Tahltan coronal harmony rule (Shaw 1991)



On this analysis, the transparency of vowels and non-coronal consonants falls out straightforwardly from considerations of feature geometry: such segments are not specified on the [Coronal] tier, and do thus not constitute eligible targets for spreading. However, the same must also be true of the plain coronal series /t, t’, d, n/ and for the lateral series /ɬ, l, tɬ, tɬ’, dl/, since these are equally transparent—in spite of the fact that these consonants are all (phonetically) coronals. Here Shaw appeals to underspecification: she assumes that both series completely lack a [Place] node (and therefore also a [Coronal] node); this renders them effectively invisible to the rule in (9). Furthermore, since the lateral-series consonants are transparent, the locality condition entails that the feature [±lateral] must be located relatively high in the feature-geometric tree.[9] The (underlying) representations Shaw assumes are as shown in (10) for the /d/, /dl/ and /dð/ series. (The internal structure of /dz/- and /dʒ/-series consonants is just like that of the /dð/ series, except that the features under the [Coronal] node are [+strident] and [–anterior], respectively, in place of [+distributed].)

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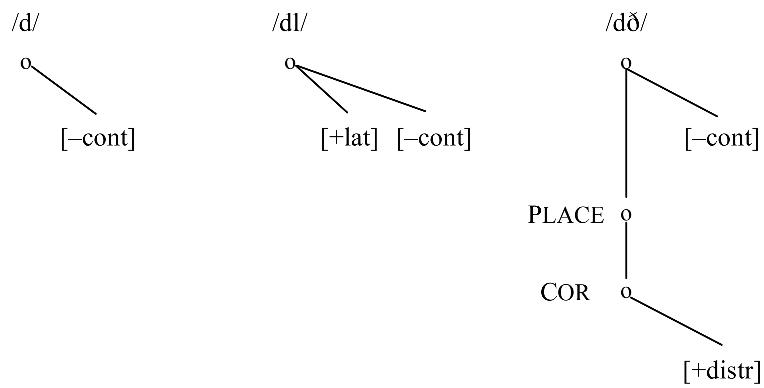
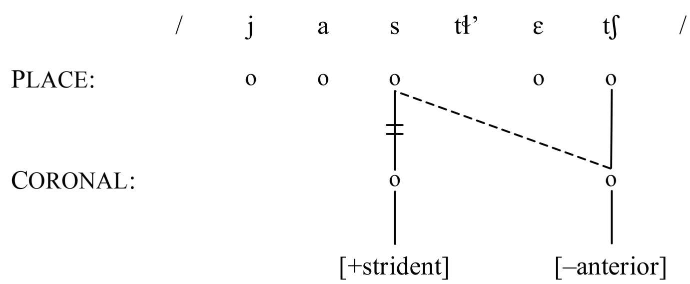
[9] Blevins (1994) suggests an alternative to the feature geometry and specifications assumed by Shaw (1991). Blevins proposes that [±lateral] is in fact dominated by the [Coronal] node, just like [±anterior] and [±distributed], but that the latter are embedded under an intermediate class node [Central], rather than being direct dependents of [Coronal]. Tahltan coronal harmony can then be viewed as leftward spreading of the [Central] node; Blevins’ rule for Tahltan is identical to (9), if we substitute [Coronal] for [Place], and [Central] for [Coronal].

(10) Underspecified input representations of Tahltan coronals (Shaw 1991)



Given these representational assumptions, the transparent behavior of the plain coronal series and the lateral series is accounted for, as shown by the example in (11), which represents the derivation /ja-s-tɬ'ɛtʃ/ → [jaʃtɬ'ɛtʃ] 'I splashed it'. Note that the lateral affricate /tɬ'/ lacks a Place node altogether; this allows the [Coronal] specification to spread uninterrupted from the trigger /tʃ/ directly to the target /s/ by the rule stated in (9) above.

(11)

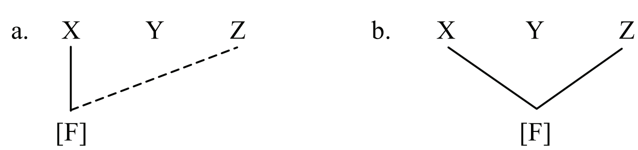


With the advent of output-oriented constraint-based frameworks, in particular Optimality Theory (OT; Prince & Smolensky 2004 [1993]), the device of underspecification cannot be used as liberally as in previous rule-based architectures. Most analyses along the lines of Shaw (1991) assume that while a consonant like /tɬ'/ is 'placeless' at the level of underlying (lexical, input) representation, it does nevertheless get specified as [Coronal] (and [+anterior], etc.) in the eventual *surface* (output) representation. That is, other phonological rules will subsequently insert predictable and/or default feature values on underspecified segments—severing or 'splitting up' feature-sharing configurations like those resulting from (9)/(11) wherever necessary. If the assumption of full output specification is carried over into OT, where all phonological processes are driven by constraints on surface representations, and where all constraints are evaluated in parallel, underspecification (of input segments) is of no use in accounting for transparency effects. If the coronal harmony requirement is a well-formedness constraint on output representations, and if that constraint can only be satisfied by means of [Coronal] spreading, then any segment that is specified as [Coronal] on the surface will participate in the harmony, either as a trigger, target, or blocker, regardless of whether it carried a [Coronal] specification in the input.

Some OT analyses of transparency effects in *vowel* harmony have allowed for underspecification in phonological output representations (Ringen & Vago 1998, Ringen & Heinämäki 1999; see Itô et al. 1995). This effectively relegates the assigning of certain unmarked feature values—such as [–back] in the non-low unrounded vowels of Finnish or Hungarian, which are transparent to [+back] harmony—to a separate module of phonetic interpretation. Note, however, that this is rather different from what is assumed in *phonetic underspecification* models (Keating 1988, Cohn 1993, Choi 1995), where the realization of underspecified output segments is determined by 'target interpolation'. It would be inconceivable for a high unrounded vowel, unspecified for backness but surrounded by [+back] vowels on either side, to become phonetically realized as a *front* vowel [i] (e.g. in an [u…i…o] sequence) by interpolation alone.

As described above, most autosegmental analyses of harmony as feature spreading adopt a notion of *relativized locality* (Goldsmith 1979, Clements 1980, Kiparsky 1981, Clements & Sezer 1982, Steriade 1986, 1987, 1995, Odden 1994; cf. also Calabrese 1995, Vaux 1999, Halle et al. 2000, Nevins 2005). Autosegmental phonology attempts to preserve a principled and constrained definition of locality by assuming that harmony is relativized to some particular class of 'legitimate target' segments. As long as no legitimate target is being skipped by the spreading feature, locality is obeyed. Any number of intervening segments (vowels and/or consonants) can be skipped (i.e. transparent), as long as none of these constitutes a legitimate target; that is, the multiply-linked harmony feature is allowed 'straddle' these segments, without being associated with them. Harmony may thus spread the phonological feature [F] from X to Z across an intervening Y, as in (12a), as long as Z but not Y belongs to the class of designated targets (and as long as no association lines are crossed). Consequently, feature-spreading analyses that are based on relativized locality crucially allow for *gapped representations* as in (12b), where a single featural element [F] is associated with segments X and Z without being associated with the intervening segment Y.

(12) Gapped representations:



If all harmony involves spreading, and if relativized locality is taken to be the source of all transparency effects, then gapped configurations like (12b) must be allowed for, if not in the surface representation then at least at some level of representation intermediate between input and output. As we saw above, maintaining locality in this manner often requires that underspecification be invoked—a notion which is difficult to reconcile with the output-oriented parallelist architecture of Optimality Theory. Quite aside from the underspecification problem, a series of works in the OT tradition have gone so far as to propose that gapped representations be ruled out altogether, and that the notion of relativized locality be abandoned, with severe implications for the analysis of consonant harmony.

1.2.3. Consonant Harmony and Strict Locality

A series of works argues for an alternative and much more stringent view of locality in feature spreading, usually referred to as Strict Locality, whereby gapped representations like (12b) are deemed to be universally ill-formed phonological structures (Archangeli & Pulleyblank 1994, Flemming 1995, Gafos 1999 [1996], Pulleyblank 1996, Ní Chiosáin & Padgett 1997, 2001, Walker 2000b [1998], Padgett 2002). Instead, all spreading is taken to be strictly local at the segmental level, such that nothing is ever 'skipped': all segments within a spreading domain are participants, targeted by (and hence carrying) the spreading feature. In most cases, proponents of strict locality advocate a fairly concrete interpretation of phonological features and of the phonology-phonetics mapping, whereby feature specifications are equated with or mapped directly onto phonetic targets. On one version of this view (see Gafos 1999 in particular), each featural element (autosegment) in the phonological output representation stands for a single articulatory *gesture* in the sense of the Articulatory Phonology model (Browman & Goldstein 1986, 1989, 1990, 1992, Goldstein & Fowler 2003). By definition, a gesture spans a particular interval in time, and feature spreading is thus tantamount to the *temporal extension* of a gesture, leading it to encompass two or more segments. From this perspective, a gapped representation such as (12b) is nonsensical: if the single articulatory gesture corresponding to [F] overlaps (in time) with segments X and Z, then it must overlap Y as well.[10]

Starting with Öhman (1966), phonetic studies of vowel-to-vowel coarticulation have consistently indicated that in a string VC_0V, the vocalic gestures are articulatorily contiguous across the intervening consonant(s). The gestures of the intervening consonants are superimposed on these vocalic gestures and thus coarticulated with them. Proponents of the strict locality approach often cite this as evidence that intervening consonants in vowel harmony are not 'skipped' by the spreading feature (e.g. a gesture of lip rounding or tongue-root retraction) but rather *permeated* by it. From this perspective, the intervening consonants are harmony targets no less than the vowels flanking them. The sole difference is that the effect that the spreading vocalic gesture has on consonantal targets has no phonological repercussions. Strictly speaking, the surface realization of /t/ in a [–back] harmony span like […iti…] or a [+round] harmony span like […ɔtu…] is [t^j] and [t^w], respectively (Ní Chiosáin & Padgett 2001). However, as long as consonant palatalization or labialization is not contrastive in the language in question, and no other constraint or phonological process is sensitive to it, this fact has no impact on the phonology of the language.

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[10] Purely formal arguments have also been raised against (12b), for example that it entails contradictory precedence relations (Archangeli & Pulleyblank 1994, Pulleyblank 1996).

The implications of the strict locality hypothesis for consonant harmony systems have been explored most thoroughly by Gafos (1999 [1996]). Gafos assumes a one-to-one correspondence between phonological features and articulatory gestures, and hence equates feature spreading with the temporal extension of a single continuous gesture. Since skipping of intervening segments is thereby inconceivable, all segments that give the appearance of being transparent must be construed as being permeated by the spreading gesture. Gafos (1999) argues that the cross-linguistic typology of consonant harmony systems supports this view. Based on a survey of coronal harmony systems, he notes that the features involved are correlated with gestures carried out by the tongue tip/blade. The relevant gestural parameters are defined as Tongue-Tip Constriction Orientation (TTCO) and Tongue-Tip Constriction Area (TTCA). As a semi-independent articulator, the tongue tip/blade is not actively employed in the production of vowels or non-coronal consonants, and the superimposition of tongue-tip gestures on such segments has little noticeable effect on their acoustic realization. Therefore, TTCO and TTCA settings are precisely the kinds of properties that would be expected to be involved in consonant harmony, since they are able to spread undisturbed (and largely unnoticed) through intervening segments.

In support of this interpretation of coronal harmony by Gafos (1999; cf. Flemming 1995, Ní Chiosáin & Padgett 1997), the study on consonant-to-consonant coarticulation by Bladon & Nolan (1977) is frequently cited as evidence for the plausibility of the analysis. This study found that in English words like *sat*, *does*, *sedan* and *deserve*, the stops [t, d] show a slight coarticulatory shift in tip-blade configuration towards that of the nearby [s] or [z] (which were found to be consistently laminal). This can be taken as confirmation that tip-blade gestures *can* in principle extend across an intervening vowel, and hence that coronal consonants can interact articulatorily in CVC contexts.[11] Although none of the findings reported by Bladon & Nolan (1977) bear on the question whether tip-blade gestures can also coarticulate across an intervening non-coronal consonant (e.g. in a CVmVC or CVkVC context), there is little reason to doubt that this is the case. For example, the English [l] vs. [ɹ] distinction has been found to have acoustic consequences (e.g. lowering of F2 and F3 in the case of [ɹ]) that span several syllables (Kelly & Local 1986, Kelly 1989, Newton 1996, Tunley 1999; see Blevins & Garrett 2004). Moreover, Walker et al. (2008) have demonstrated that in the sibilant har-

[11] Interestingly, the stops /t, d/ were precisely the ones whose articulation (in non-coarticulation contexts) was the least uniform across the pool of subjects in the study by Bladon & Nolan (1977). Whereas /l, n/ were consistently apical, and /s, z/ consistently laminal, individual speakers varied much more in the articulation of /t/ and /d/. Unfortunately, the study gathered no data on possible coarticulatory effects on /l, n/ across vowels. Note, however, that in the fricative-stop and stop-fricative CVC sequences, the fricatives /s, z/ remained laminal. Unlike the stops, the fricatives were thus unaffected by coarticulation; this may well be connected to the fact that they were consistently laminal across subjects as well. In short, the study by Bladon & Nolan (1977) raise a number of additional questions which may have a bearing on the validity of the gestural-extension analysis of coronal harmony.

mony of Rwanda (Kinyarwanda), the retroflexion gesture (a 'tip-up' posture of the tongue blade) does indeed carry on through intervening non-coronal consonants like [m]—though they conclude, based on the unique opacity effects exhibited by this particular case (Walker & Mpiranya 2005; see §3.2.2 below), that it is different in kind from other instances of consonant harmony.

Given that the Strict Locality hypothesis emerged (largely) in the context of the constraint-based Optimality Theory framework, proponents of the gesture-extension approach to coronal harmony have typically formalized their analyses within that model. As such, these analyses will be discussed in §4.1.1 below, where other OT analyses are also described. In that section, certain empirical flaws of the gesture-extension analysis are discussed in greater detail than is possible here. The main arguments are the following. Firstly, Gafos (1999) is incorrect in claiming that 'consonant harmony is *attested only* for coronal consonants' and that the features which assimilate in consonant harmony 'are *limited to* those which describe the mid-sagittal or cross-sectional shape of the tongue tip-blade' (pp. 125–126; emphasis added). If consonant harmony is given a descriptive definition, (relatively) free of analytical preconceptions, as was attempted in (2) above, then non-coronal harmony most certainly does exist, as will be amply documented in the survey of chapter 2. To categorize such phenomena as something *other* than 'consonant harmony', in order to rescue the predictions of the strict locality hypothesis, introduces a circularity which renders that hypothesis vacuous and unfalsifiable in principle.

Secondly, the gesture-extension analysis of coronal harmony advocated by Gafos (1999) frequently requires that one call into question a number of clear and unequivocal statements about the phonetics and phonology of individual coronal harmony languages in the descriptive literature. For example, if coronal harmony in Tahltan is due to strictly-local spreading, those coronals which were previously assumed to be non-targets (e.g. the plain stops and laterals) are in fact permeated by the spreading tongue-tip gesture. They should thus be *allophonically* affected, often in a way that ought to be noticeable; for example, an intervening /n/ in a /…s…n…ð…/ → […θ…n…ð…] sequence should upon closer inspection turn out to be dental [n̪]. However, descriptive sources on coronal harmony languages are consistently and conspicuously silent about such allophonic differences, even when those same descriptions provide a good deal of allophonic detail otherwise—sometimes even mentioning the occurrence of the expected allophone in other contexts, where harmony is not involved. This casts serious doubt on the empirical validity of the predictions made by gesture-extension analyses of consonant harmony.

Finally, the assumption that all consonant harmony interactions involve strictly-local spreading through intervening vowels and consonants (and possibly onwards beyond the 'target' consonant as well) predicts that segmental *opacity effects* ought to be well attested in the typology of consonant harmony. Some particular type of intervening segment might thus be incompatible with the spreading feature in the language in question; to use our earlier example, dental [n̪] may be disallowed for some reason, and /n/ would then block the spread of dentality. However, opacity effects are so vanishingly rare as to be essentially non-existent, as will be discussed at length in §3.2 below.[12] This striking difference between consonant harmony and other types of harmony phenomena (vowel harmony, vowel-consonant harmony), combined with the fact that many attested types of consonant harmony are intrinsically incompatible with the notion of strictly-local spreading, is a strong indication that some other mechanism is involved in most—perhaps all—consonant harmony systems.

From this we can draw either of two conclusions. One possibility is that the Strict Locality hypothesis is simply wrong and should be abandoned in favor of some version of Relativized Locality (see, e.g., Vaux 1999). Another alternative is to admit the possibility that not all assimilatory interactions take place by means of feature spreading, and that some phonological constraints (or rules) are able to single out pairs of segments that are not necessarily adjacent in the input or output string. This second option is taken in the present work, where it is argued that consonant harmony is the product of constraints that call for featural *agreement* between segments of a designated class (see also Walker 2000a, 2000c, 2001, Rose & Walker 2004; cf. Pulleyblank 2002).

1.3. Central Claims

The most obvious and least disputable assertion made in this work is that consonant harmony is not restricted to coronal harmony—that is, to assimilation in terms of coronal-specific featural distinctions or articulatory gestures. As the extensive survey in chapter 2 demonstrates, long-distance consonant assimilations may involve a wide variety other phonetic/phonological properties; these include voicing, degree of constriction, nasality, uvularity (among dorsals), secondary articulations, rhoticity, and so forth. In terms of their typological profile, coronal harmony systems do not stand out in any way that might suggest that these, unlike other types of consonant harmony, are due to strictly-local spreading or gestural extension along the lines described in the previous section. With respect to their typological characteristics, all the

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[12] It should be noted that transparent vowels in *vowel harmony* systems remain a genuine challenge for Strict Locality (as acknowledged by Ní Chiosáin & Padgett 1997). Phonetic investigation has revealed some reported cases of transparency to be illusory, in that the vowels in question appear to be permeated by the spreading property (Rialland & Djamouri 1984, Gick et al. 2006; though such studies often do not exclude local V-to-V coarticulation as a possible cause, e.g. for Benus & Gafos' 2007 Hungarian results). However, many cases remain for which this is not a plausible explanation. In general, various special devices have been proposed to deal with transparent vowels in OT: nested feature spans (Smolensky 1993, Kaun 1995, Kirchner 1997), non-expression of a feature on certain segments within its span (Cole & Kisseberth 1994, O'Keefe 2005), reference to a separate representation (e.g. a failed candidate output) where the vowel in question is affected (Ní Chiosáin & Padgett 1997, Baković 2000, Baković & Wilson 2000; see also Walker 2000b, 2003 on nasal harmony), constraint conjunction (Krämer 2002, 2003, Kiparsky & Pajusalu 2003), or a revised mode of evaluation for featural alignment constraints (Pulleyblank 1996, Orie 2001).

subtypes of consonant harmony surveyed here, coronal and non-coronal harmony alike, form a coherent class.

What is more, the typology of consonant harmony systems differs from that of vowel harmony in several striking respects which have not been noted by previous researchers, and which are the focus of chapter 3. For example, consonant harmony is never sensitive to prosodic factors in any way (by stress, syllable weight, segmental length, foot structure, etc.), whereas this is quite common for vowel harmony systems. Moreover, prosodic factors are very often implicated in vowel-consonant harmony processes, such as nasal harmony or pharyngealization spreading—where the harmony trigger is often a consonant (as are many of the target segments), just like in consonant harmony. If nasal harmony and sibilant harmony are both due to feature spreading, then there is no immediately obvious reason why the latter could not be constrained (or otherwise affected) by prosodic factors, just as the former can.

Another glaring difference that emerges from a typological comparison of consonant harmony with other kinds of harmony systems is the fact, mentioned earlier, that consonant harmony is consistently oblivious to the properties of the segments intervening between the trigger and target consonants (with one or two exceptions; see §3.2.2 and §3.2.3). Any and all segments that are not direct participants in the harmony are almost universally 'transparent' (i.e. inert) to the point of being irrelevant to the harmony. By contrast, both vowel harmony and vowel-consonant harmony systems very frequently display segmental opacity effects, whereby a particular class of non-participating segments blocks the propagation of the harmonizing property. This difference would be highly surprising if consonant harmony were due to the very same mechanism as the other types of harmony phenomena, namely the (strictly-local) spreading of features or articulatory gestures.

Based on these considerations, another major claim put forward here is that consonant harmony (including coronal harmony) is not to be understood as being based in feature *spreading* at all—neither strictly-local spreading nor the kinds of long-distance spreading permitted under relativized locality. Rather, consonant harmony is a matter of satisfying demands for (long-distance) *agreement* between consonants of a particular type. In the Optimality Theory analysis of consonant harmony developed in chapters 4 and 5, this agreement is formalized in terms of syntagmatic correspondence. The formal analysis is based on, and is largely identical to, the Agreement by Correspondence (ABC) model developed by Walker (2000a, 2000c, 2001; see also Rose & Walker 2000) and presented in detail in Rose & Walker (2004).[13] Since consonant harmony is not due to spreading but to agreement—mediated by an

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[13] The original manuscript version of Rose & Walker (2004) was circulated a few months before the completion of the dissertation on which this monograph is based (Hansson 2001b), revealing significant overlap between the research endeavors underlying the two works, both in empirical coverage and in many aspects of the formal analysis. Just as the 2004 published version of Rose & Walker's article makes copious reference to individual cases reported in Hansson (2001b), as well as to various empirical observations and analytical issues raised in that work, so too does the present revision of Hansson (2001b) draw useful analytical insights

abstract correspondence relation between segments that are potentially non-adjacent—it is not bound by the Strict Locality requirement that has been claimed to govern feature spreading. Under the correspondence-based agreement analysis, the systematically transparent (rather than opaque) behavior of intervening segments becomes the expected norm rather than a special case, unlike for spreading-based phenomena like vowel harmony and vowel-consonant harmony. Agreement merely requires matched feature values, not the 'sharing' of a single featural autosegment (or articulatory gesture); the only segments subject to agreement are those that are linked by a correspondence relation. For this reason, vowels and consonants that intervene between the two corresponding correspondence are not expected to be able to block or hinder the agreement in any way, other things being equal.

In the ABC model, the main factor that contributes to establishing the correspondence relations which serve as the 'vehicle' for long-distance consonant assimilations is taken to be the relative *similarity* of the two consonants (as well as their distance from one another). The more similar (and less distant) two consonants are, the stronger the drive towards agreement in any of the feature or features that differentiate them. The role of relative similarity, which has also been found to be a conditioning factor in dissimilatory co-occurrence restrictions (Frisch et al. 2004), strongly suggests that consonant harmony is connected to the domain of *speech planning*—that is, phonological encoding for speech production. Similarity plays a clear role in facilitating the occurrence of slips of the tongue: the more alike two co-occurring consonants are, the more likely one is to interfere with the other during the planning process, potentially resulting in a phonological speech error. Under the analysis presented in this work, consonant harmony could to a certain extent be said to constitute the 'phonologized' counterpart of speech errors.

In support of this view, several additional parallels between phonological speech errors and consonant harmony processes are adduced throughout this work. Most of these had gone unnoticed by previous works on consonant harmony. Perhaps the most obvious parallel is the fact that the segment contrasts that most often form the basis of consonant harmony, sibilant distinctions like /s/ vs. /ʃ/, are also the ones most commonly employed in conventional tongue-twisters in many languages, (cf. the early observations of Jespersen and Harrington in §1.2.1 above), which in turn reflects how prone such segments are to interact in slips of the tongue. Another indication is the prevalence and default status of anticipatory (regressive, right-to-left) directionality in consonant harmony, which had not been noted prior to Hansson (2001b). As Dell et al. (1997) point out, any well-designed serial-order production system must prepare to activate upcoming elements at the same time as the current element is being executed, whereas past elements must be promptly deactivated once they have been produced. As a result, interference effects are more likely to be anticipatory (the future influencing the present) than perseveratory (the past influencing the present), and this asymmetry does indeed

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and important data from Rose & Walker (2004) and related works by the same authors (e.g. Rose 2004, Walker & Mpiranya 2005, Rose & King 2007, Walker et al. 2008, Walker 2009a, 2009b). See also n. 17 in chapter 4.

hold quite robustly for speech error data. A third parallel, which was likewise first noted in Hansson (2001a, 2000b) is the curious phenomenon referred to by Stemberger (1991) as the Palatal Bias effect, which is discussed at length in chapter 6. The essence of the Palatal Bias is that alveolars like /s/ are far more susceptible to interference from (= assimilation to) 'palatals' like /ʃ/ than vice versa. An important finding of the present study is that the same asymmetry characterizes the cross-linguistic typology of coronal harmony systems—not merely those involving sibilant harmony, but also those rare cases in which alveolar stops and 'palatal' affricates interact (/t, d/ vs. /tʃ, dʒ/).

Taken together, such parallels between phonological speech errors and consonant harmony systems provide strong evidence in support of the view that consonant harmony has its roots in the domain of speech planning—which is in turn what underlies the correspondence-based ABC analysis of consonant harmony developed in detail in chapters 4 and 5. This applies to many non-coronal harmony phenomena, such as nasal consonant harmony, where intervening segments are quite clearly transparent to (and unaffected by) the propagation of nasality from one consonant to another. More importantly, these pervasive parallels hold no less strongly for of coronal harmony systems, where it would in principle be *conceivable* that intervening vowels and consonants are permeated by the harmonizing feature/gesture, as conjectured by Gafos (1999) and others. For this reason, it seems safe to conclude that coronal harmony is (at least in the vast majority of cases) based on long-distance agreement rather than strictly-local spreading.

It should be emphasized that this conclusion is by no means tantamount to rejecting the Strict Locality hypothesis as such. The view that all spreading respects segmental adjacency, and that feature spreading can never 'skip' segments, is fully compatible with the notion that consonant harmony interactions involve some mechanism *other* than spreading (namely agreement). The general validity of the Strict Locality hypothesis is thus largely irrelevant in this context and will not be addressed in the present study. Likewise, the conclusion that consonant harmony is due to long-distance agreement rather than spreading invites the possibility that certain *vowel harmony* systems—especially ones with (genuinely) transparent vowels—might be properly analyzed in the same way. Just as a feature like [nasal] can define harmony either by local spreading (= nasal harmony) or by non-local agreement (= nasal consonant harmony), so too might a vowel feature like [round] be subject to long-distance (correspondence-based) agreement in some cases, rather than local (adjacency-based) spreading. This intriguing question will be left to future research, but it is worth noting that non-local agreement constraints have been proposed for vowel harmony by Pulleyblank (2002), and attempts have recently been made to extend the ABC model to certain vowel harmony systems (Hansson 2006a, Rhodes 2008, Walker 2009b).[14]

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[14] In his treatment of vowel harmony, Baković (2000) proposes to eliminate the representational device of autosegmental spreading altogether, suggesting that all assimilation be construed as due to (local) agreement constraints (for related proposals see Pulleyblank 2002, Krämer 2003). On this view, the Strict Locality hypothesis translates into the assertion that

1.4. Organization of the Book

The remainder of this book is organized as follows. Chapter 2 presents a detailed overview of attested cases of consonant harmony, classified by the phonological property on which the harmony is based. This overview summarizes the findings of a detailed cross-linguistic survey, cataloguing nearly 150 documented examples (from more than 120 languages) of sound patterns that fit the definition of consonant harmony laid out in §1.1 above. Chapter 3 discusses several important empirical generalizations that emerge from the survey and that place consonant harmony in sharp contrast to both vowel harmony and vowel-consonant harmony. Chapters 2 and 3 thus form the 'empirical backbone' of this work. Because they are based on the most extensive survey of consonant harmony phenomena to date, it is my hope that they will serve as a useful resource for future research in this area. As such, the findings reported in chapters 2 and 3 are relatively independent of any particular theoretical assumptions or formal frameworks.

Chapters 4 and 5 develop a generalized formal analysis of consonant harmony within Optimality Theory. As mentioned above, this analysis is based on the Agreement by Correspondence (ABC) model (Walker 2000a, 2000c, 2001, Rose & Walker 2000, 2004), but with some notable differences. For example, the analysis developed here makes crucial use of the notion of *targeted constraints* (Wilson 2000, 2001, 2003, 2006, Baković 2000, Baković & Wilson 2000), which are used in a novel way to account for fixed-directionality effects.

The proposed analysis interprets consonant harmony as correspondence-based agreement. As explained above, this is based on the hypothesis that consonant harmony has its roots in the domain of speech planning and that it shares significant affinities with phonological speech errors. Chapter 6 discusses at length the arguments for this link between consonant harmony and speech errors, with particular focus on the existence of Palatal Bias effects in the cross-linguistic typology of coronal harmony systems. Finally, chapter 7 summarizes the conclusions of this study and brings up various outstanding issues for future research, including the relationship between consonant harmony processes in child language and the (adult) consonant harmony phenomena surveyed here, as well as the (possibly varied) diachronic origins of consonant harmony sound patterns.

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agreement is evaluated for pairs of (articulatorily) *adjacent* segments only. So-called 'unbounded spreading' phenomena (vowel-consonant harmony) involve satisfying agreement over a chain of adjacent-segment pairs (Wilson 2003, 2006). This perspective brings the analysis of vowel harmony and vowel-consonant harmony phenomena much closer to that developed for consonant harmony in this study (even if spreading is allowed as a representational means for satisfying agreement; Hansson 2007b), but the full implications have yet to be explored in detail.

2. A CROSS-LINGUISTIC TYPOLOGY OF CONSONANT HARMONY

Prior to the appearance of the doctoral dissertation on which this monograph is based (Hansson 2001b) and of Rose & Walker (2004), our understanding of consonant harmony, and of its relationship to other types of harmony phenomena, was seriously hampered by the lack of a comprehensive cross-linguistic survey of consonant harmony systems. In the absence of a large-scale typological study, it is difficult to draw any valid empirical generalizations about sound patterns of this kind. Among the relevant issues are the following:

- For what phonetic/phonological features is consonant harmony attested?
- How is the subset of interacting consonants (harmony triggers and targets) demarcated?
- Are intervening segments always transparent to consonant harmony, or may certain types of segments act as opaque blockers of the harmony?
- Is the distance between the trigger and target consonants a factor, and if so, how is it quantified?
- What directionality patterns are attested in consonant harmony systems?
- To what extent is consonant harmony sensitive to morphological structure?
- To what extent is prosodic structure relevant for the operation of consonant harmony?

Formal-generative analyses of consonant harmony need to take into account any significant generalizations that might emerge from an examination of issues like the above. Such generalizations are also likely to shed light on the possible motivations (articulatory, perceptual, psycholinguistic, cognitive) of consonant harmony and on the diachronic emergence and development of such sound patterns in language change. The need for a detailed empirical survey, as unbiased as possible by analytical and theoretical preconceptions, is made all the more acute by the fact that consonant harmony is much less well known and poorly understood in comparison to vowel harmony. In part for this reason, the former has typically been analyzed in the same terms as the latter, without much in the way of independent justification.

The typological overview presented in this and the following chapter aims to fill this gap. It constitutes the most thorough and extensive survey to date of consonant harmony systems in the world's languages, their parameters of variation and shared typological characteristics. The most notable finding to emerge from this survey is that consonant harmony displays a typological profile which is markedly different on several counts from that of vowel harmony, as well as from those harmony systems that exhibit unbounded feature spreading, what is here referred to as vowel-consonant harmony (nasal harmony, pharyngealization spreading, and so forth). Some of these typological asymmetries, and their implications for our understanding of the nature of consonant harmony as such, are discussed in chapter 3. The findings of this cross-linguistic survey provide the empirical basis for the formal analysis of consonant harmony laid out in chapters 4 and 5.

The structure of this chapter is as follows. The findings of previous survey-oriented works on the topic are discussed in §2.1. The database underlying the present survey is described in §2.2. In a considerable number of cases, consonant harmony is manifested only in the form of static co-occurrence restrictions within root morphemes. In §2.3 such cases are compared to ones where harmony is actively manifested in alternations arising from morpheme concatenation, and the inclusion of the former as equally valid instances of consonant harmony is justified. The bulk of the chapter is taken up by section §2.4, which lists the various types of consonant harmony systems exemplified in the database, classified according to the phonetic-phonological property over which the assimilatory interaction (or co-occurrence restriction) is defined. As several of the attested types of consonant harmony are virtually unknown, a point has been made of including a wide range of illustrative examples, especially of the relatively rarer types (e.g. liquid harmony, dorsal harmony, stricture harmony); references to the relevant descriptive sources are provided throughout. As a result, the overview as a whole is quite lengthy, but will hopefully serve as a valuable source of data and references for future research on consonant harmony and related phenomena. Finally, the main findings are summarized in §2.5, where some problematic issues are also raised regarding the classification used and its formalization in featural terms.

2.1. Previous Surveys of Consonant Harmony

Although the present survey is the first truly comprehensive one of its kind, it is not without predecessors. A few earlier works have made more modest attempts at exploring the cross-linguistic typology of consonant harmony, the first being Shaw (1991). Shaw's survey is based on a somewhat wider definition of the term 'consonant harmony' than the one used in this study, namely 'phonological assimilation *or dissimilation* between consonants that are not necessarily adjacent in the surface string and where, crucially, other intervening vocalic or consonant segments do not interact with the harmony in any way' (Shaw 1991:125; emphasis added). In addition, Shaw includes what she (following Cole 1991) refers to as 'morphological harmony'. These are cases 'where the harmony instantiates or signifies a particular morpheme' (Shaw 1991:128); that is, instances of *featural affixation* (Akinlabi 1996). It is true that consonant harmony in the strictest sense—assimilatory interactions among co-occurring consonants—might well be involved in some cases of this type (namely ones where the featural affix surfaces on multiple segments in the base; see the discussion of Harari in §2.4.1.2 below). However, this is by no means certain, and one should be wary of putting 'morphological harmony' on a par with purely phonological consonant-to-consonant interactions, at least from a synchronic perspective (a point made by Cole 1991 and acknowledged explicitly by Shaw 1991).

Once we filter out all of the dissimilatory cases, as well as those examples of 'morphological harmony' that do not involve multiple targets, the list of cases covered by Shaw's consonant harmony survey is as shown in (1). The questionable status of the so-called morphological harmony cases is highlighted by enclosing these in brackets. References have been omitted for cases that are discussed in detail elsewhere in the present work.

(1) Shaw's (1991) cross-linguistic survey of consonant harmony (abridged)

- a. Laryngeal Harmony
  - [Salish diminutive glottalization (Reichard 1938, Mattina 1973, Cole 1991)]
  - [Nisga'a ʔ-spread (Shaw et al. 1989)]
- b. Place Harmony
  - Coronal Harmony
    - Tahltan coronal harmony
    - Navajo sibilant harmony
    - Chumash sibilant harmony
    - (Southern Peruvian) Quechua sibilant harmony
    - Rwanda (Kinyarwanda) sibilant fricative harmony
    - Wiyot coronal harmony
    - Sanskrit *n*-retroflexion
    - [Harari dental palatalization]
  - Labial Harmony
    - (not attested)
  - Dorsal Harmony
    - (not attested)
  - Pharyngeal Harmony
    - (not attested)

As can be seen from the list in (1), Shaw (1991) is aware of only 7 attested cases of consonant harmony in the strict (non-'morphological') sense. All of these involve contrasts among coronal consonants, typically sibilants. Even in Wiyot and Tahltan, where non-sibilants participate in the harmony, sibilant distinctions like [s] vs. [ʃ] are among those over which harmony operates. Furthermore, one of the cases listed by Shaw, Sanskrit *n*-retroflexion, is highly suspect as a case of consonant harmony, as will be argued at length in §3.2.3 below.

A more ambitious survey is put forward by Gafos (1999), who expands on Shaw's findings and states outright that coronal harmony is the only attested type of consonant harmony. In fact, Gafos goes further, suggesting that coronal harmony is the only *possible* type, inasmuch as it alone involves the kind of articulatory gestures which are able to spread without interfering with the production or perception of intervening vowels and (non-coronal) consonants. As was explained in §1.1 above, however, this bold hypothesis is unfortunately weakened by a certain circularity, in that the scope of the survey in Gafos (1999) seems to be deliberately confined to those consonant harmony phenomena that fit the coronal harmony rubric. No attempt is made to deal with (or even mention) alleged cases of consonant harmony involving *non*-coronal features/gestures, for example by explaining these as being due to something other than 'harmony'. No attempt is made to deal with (or even mention) alleged cases of consonant harmony involving *non*-coronal features/gestures, such as the various examples of nasal consonant harmony, voicing harmony or liquid harmony that are described and illustrated in Odden (1994). Be that as it may, the cross-linguistic study of Gafos (1999) is highly valuable as a source on the typology of *coronal* harmony in particular.

The coronal harmony systems surveyed by Gafos (1999) are listed in (2). These are grouped according to the gestural parameter which Gafos infers to be the basis of the harmony. Those in (2a) involve Tongue-Tip Constriction Orientation (TTCO; 'tip-up' vs. 'tip-down'), which is assumed to underlie not only the apical/laminal contrast in Chumash but also the retroflex/dental contrast in Sanskrit and the Northern Australian languages Gooniyandi and Gaagudju. The other parameter, Tongue-Tip Constriction Area (TTCA), with the three possible values 'wide', 'mid' and 'narrow', is taken to be the basis of coronal harmony in Tahltan, which involves a three-way contrast like [θ] vs. [s] vs. [ʃ] (2b). Finally, for the systems listed here under (2c), Gafos does not explicitly discuss whether the parameter involved is likely to be TTCA or TTCO. The first four of these are languages of the Athapaskan family, whose harmony systems are historically cognate with the Tahltan one. With the exception of Rwanda (Kinyarwanda), the other languages in (2c) are simply listed without further discussion of their phonetic/phonological nature, except for the fact that harmony in these languages is confined to coronal fricatives and affricates, all other segments being transparent. In some cases it appears clear that TTCO rather than (or in addition to) TTCA is involved, for example in Basque, where the relevant distinction is an apical vs. laminal contrast (Hualde 1991, Trask 1997).

(2) Coronal harmony systems surveyed by Gafos (1999)

a. Articulatory parameter: Tongue-Tip Constriction Orientation (TTCO)
   - Chumash sibilant harmony
   - Sanskrit *n*-retroflexion
   - Gooniyandi retroflexion harmony
   - Gaagudju retroflexion harmony

b. Articulatory parameter: Tongue-Tip Constriction Area (TTCA)
   - Tahltan coronal harmony (three-way: dental/alveolar/postalveolar)

c. Articulatory parameter uncertain or not discussed
Tsilhqot'in (Chilcotin) sibilant harmony
Navajo sibilant harmony
Chiricahua Apache sibilant harmony
Plains Apache ('Kiowa-Apache') sibilant harmony
Rwanda (Kinyarwanda) sibilant fricative harmony
Moroccan Arabic sibilant harmony
Basque sibilant harmony
Imdlawn [Tashlhiyt] Berber sibilant harmony
Ntifa [Tamazight] Berber sibilant harmony
Southern Paiute sibilant harmony
Tzeltal sibilant harmony

Gafos (1999) thus finds 16 attested cases of consonant harmony, all involving coronal consonants. Of these, 5 were among the 7 cases mentioned earlier by Shaw (1991). The two that remain are (Southern Peruvian) Quechua and Wiyot. Gafos rejects the latter as a plausible case of consonant harmony, interpreting the Wiyot facts instead as 'consonant symbolism', akin to other sound symbolism systems found throughout North America, especially along the Pacific coast (Haas 1970, Nichols 1971). He is certainly right in drawing a clear distinction between consonantal sound symbolism and consonant harmony, and in pointing out that 'some cases of consonant symbolism have been misinterpreted as examples of consonant harmony' (Gafos 1999:230–31). However, as noted in §1.2.1, Wiyot is a rather more complex case than this, and appears to involve *both* symbolism and harmony, with the two phenomena partly overlapping in their effects and the segments involved (Teeter 1959, 1964).[1]

To sum up, the combined surveys of Shaw (1991) and Gafos (1999) cover 18 consonant harmony systems, all of which are specific to coronal consonants. In addition to these two surveys, other works of more limited scope are worth mentioning in this context. Odden (1994) is concerned with general issues of locality and adjacency in phonological processes, and thus covers a wide range of assimilatory and dissimilatory interactions, both local and

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[1] There is a considerable number of languages where sound symbolism coexists with consonant harmony (i.e. long-distance assimilation among consonants) and where both revolve around the same consonantal distinctions. While the two are clearly distinct phenomena from a synchronic perspective, this fact suggests that consonant harmony might in some cases be *diachronically* linked to sound symbolism. As noted in §1.2.1 above, one possibility is analogical reanalysis: that the pervasive 'agreement' patterns that result from across-the-board sound symbolism might occasionally be reinterpreted (by learners) as reflecting a requirement for phonological assimilation—which then in turn is generalized to novel (non-sound-symbolic) contexts. Although this is an interesting topic of investigation, especially as regards the potential diachronic origins of consonant harmony, it falls outside the scope of this study (but see §6.3.3 for further discussion).

long-distance. Many of these involve consonant-consonant assimilations, which count as consonant harmony for the purposes of the present study. In addition, MacEachern (1999) gives a thorough and valuable survey of co-occurrence restrictions regarding laryngeal features in particular. Though most of the effects MacEachern discusses are dissimilatory in nature, some can be interpreted as assimilatory and may thus count as potential instances of consonant harmony.

The survey presented in this chapter, and the database on which it is based, is radically different in both size and scope from those reported in previous studies. Instead of covering only one or two dozen cases, this typological survey reports on a database containing almost 150 separate cases of consonant harmony. These are quite diverse, not merely in terms of geographic distribution and genetic affiliation, but also with respect to their phonological characteristics. The resulting picture of the 'flora' of consonant harmony systems in the world's languages is quite different from that suggested by earlier surveys. Not only is it considerably richer and much more varied, but some striking consistencies emerge which indicate that consonant harmony is markedly different from other better-known types of harmony (for some of these, see also Rose & Walker 2004).

2.2. Description of the Consonant Harmony Database

As noted above, the typological survey presented in this chapter is based on an extensive database of well over 170 attested cases of consonant harmony from approximately 130 distinct languages and dialects. For the purposes of determining whether a particular sound pattern should be included, the working definition in (3) was followed (repeated from §1.1).

(3) Consonant Harmony (definition):

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

a. the two consonants can be separated by a string of segmental material consisting of at the very least a vowel; and

b. intervening segments, in particular vowels, are not audibly affected by the assimilating property.

The restriction in (3b), that intervening segments must not be audibly affected, is crucial, since this is what differentiates consonant harmony from phenomena such as the unbounded spreading of nasalization or pharyngealization ('emphasis'), where intervening vowels are quite obviously affected. Based on his thesis of strict articulatory locality, Gafos (1999 [1996]) equates coronal harmony systems with the latter kinds of phenomena, and assumes that intervening vowels and consonants *are* affected in consonant harmony—that is, that they are permeated by the spreading articulatory gesture—but that this does not yield a noticeable acoustic effect (Flemming 1995, Ní Chiosáin & Padgett 1997, 2001). As a claim about the articulatory mechanics involved in consonant harmony, this is a mere conjecture (though see the discussion of Rwanda sibilant harmony in §3.2.2.2 below). It is based not on direct investigation of the temporal dynamics of coronal gestures in languages exhibiting coronal harmony, but rather on the observation that coronal harmony by and large involves the kinds of features/gestures that *could* in principle permeate intervening segments with little or no acoustic-perceptual consequences.

As a research question, what truly happens articulatorily in intervening segments in actual coronal harmony systems is largely uncharted territory (though see Walker et al. 2008). Many attested cases of long-distance consonant assimilations which fit the definition in (3) quite clearly *do not* involve strictly-local spreading of articulatory gestures (e.g. stricture harmony or nasal consonant harmony); see §3.2.2.1 for discussion. In addition, even if intervening vowels and consonants are 'permeated' by the gesture in question, this still does not preclude the possibility that the *phonological constraints* that trigger the harmony are making reference to the (non-local) coronal…coronal sequence as such, and pay no attention to the intervening segmental material (Hansson 2007b; see §3.2.2.2). For these reasons, we may just as well assume, as a working hypothesis, that intervening segments are not affected in consonant harmony systems of any kind.

The database on which this typological survey is based consists of any and all sound patterns fitting the definition in (3) which I was able to find in descriptive and analytical sources during my dissertation research (Hansson 2001b), as well as many additional cases which I have come across (or have been pointed out to me) in the years since then, or which have been reported in more recent literature. The database spans a wide range of geographic areas and genetic groupings. Given that consonant harmony is a comparatively rare phenomenon, no attempt has been made to design the database as an areally and genetically balanced sample. Instead, all attested cases known to the author have been included. This entails that the database is not very suitable for making statistical inferences about such issues as the relative predominance of particular typological traits, areal skewings in their geographic distribution, or the like (cf. Kochetov et al. 2008). However, since the present database is an attempt at an exhaustive catalogue of attested consonant harmony cases, a statistically balanced sample of such sound patterns would presumably constitute a subset of this database.

All in all, the database contains between 170 and 180 separate cases of consonant harmony. The Appendix gives a list of these in condensed format. The term 'separate case' deserves some qualification here. As the reader will notice, closely related languages with the same type of harmony systems are often listed as separate entries, even though the consonant harmony phenomena they exhibit are no doubt cognate and sometimes identical or nearly so. To take one example, over 15 cases of nasal consonant harmony in Bantu languages are listed individually (and many more could no doubt be adduced). While this may seem odd, it is a sound and well motivated strategy. The main goal of this survey is to gather enough empirical data to uncover generalizations about consonant harmony patterns as these are manifested in the synchronic phonologies of the world's languages. One and the same harmony phenomenon, when attested in two closely related languages, may (and often will) differ in crucial details that are of potential relevance to the overall typology. Regardless of their common historical source, cognate harmony systems in related languages deserve being listed individually because they *could* be different.

Bantu nasal consonant harmony is a case in point. In most such languages, there is a proximity restriction on trigger-target consonant pairs, such that these may at most be separated by a vowel (Bemba, Lamba, Luba, Ndonga, etc.). A few languages relax this restriction in favor of unbounded harmony (Kongo, Mbundu, Yaka). At least one language seems to be intermediate between the two in that the long-distance manifestation of harmony is optional (Suku). In yet others, nasal consonant harmony is confined to the root (Ganda), or is restricted to the C_2 and C_3 positions in a CVCVC stem template (Tiene, Teke, Kukuya, Izere). Nasal consonant harmony usually gives rise to [l] ~ [n] and/or [d] ~ [n] alternations in affixes, but in some languages, the alternation is between [r] and [n] (e.g. Herero), and in yet others, the harmony targets velar [k], [g] or [x] as well (Pangwa, Tiene). The effect of the harmony is typically nasalization (/l/ → [n], etc.), but it can result in denasalization (/m/ → [b]) in at least one language (Tiene). Finally, although the directionality is typically progressive (stem-to-suffix), the reciprocal suffix /-an-/ triggers regressive harmony onto the preceding stem in at least one language (Pangwa).

The all-inclusive strategy employed here is no different from that used in the earlier surveys discussed above. For example, of the 16 coronal harmony systems listed by Gafos (1999), 5 are from Athapaskan languages, whose harmony patterns are almost certainly cognate (and partly reconstructible for Proto-Athapaskan-Eyak; see Krauss 1964). Likewise, the two Australian cases Gafos mentions (Gooniyandi and Gaagudju) display extremely similar patterns and are no doubt connected areally and/or genetically. Finally, the sibilant harmonies found in the two Berber varieties he lists (Imdlawn Tashlhiyt and Ntifa Tamazight) are undoubtedly cognate, and are likely to be areally linked to the sibilant harmony found in Moroccan Arabic as well.

The point here is not to accuse others of the same misdeed, but to emphasize that inclusiveness is entirely appropriate for surveys of this particular kind. Indeed, it would have been a grave mistake to equate all Athapaskan coronal harmony systems, as these differ significantly in their specifics. In Tahltan, three series of coronal obstruents are involved (dental, alveolar, postalveolar), whereas harmony typically affects only two series in the other languages. Those two series are usually either dental vs. alveolar or else alveolar vs. postalveolar, but in Tsilhqot'in (Chilcotin) they are instead pharyngealized vs. non-pharyngealized alveolars. The languages also differ in subtle ways with respect to how harmony interacts with morphological structure: though Athapaskan coronal harmony is generally regressive (right-to-left), Navajo exhibits progressive harmony in particular /si-(i)ʃ-/ prefix sequences under certain conditions (McDonough 1991; see §3.1.2). In sum, the coronal harmonies of different Athapaskan languages, though related diachronically, must be counted as separate cases from a synchronic standpoint, and hence also for the purposes of any survey of consonant harmony systems and their parameters of variation.

The strategy of listing harmony systems in closely related languages as separate entries even when (apparently) identical can of course be pushed to the absurd. What about cases where the same harmony is found in different dialects of the same language? In this database, dialects have only been listed separately if they differ significantly in the properties of the consonant harmony phenomenon in question. As regards the inherently problematic and arbitrary dichotomy between 'language' and 'dialect', an attempt was made to follow the practice of recent descriptive sources on the family in question and to avoid the ubiquitous and overly general use of the term 'dialect' found in many works from the 19th and early 20th century. For example, the Chumashan family is treated as a group of several closely related languages (Barbareño, Ineseño, Ventureño, etc.) rather than as dialects of a single language, 'Chumash'.

It is important to note that a single language may simultaneously display more than one type of consonant harmony. These have been included here as separate entries, even in cases where it is plausible that the two types of harmony are connected (synchronically and/or historically). For example, Ngbaka exhibits an entire network of co-occurrence restrictions on homorganic consonants, where the banned combinations are: voiced vs. voiceless obstruents (laryngeal harmony), voiced oral vs. prenasalized obstruents (nasal consonant harmony), and prenasalized obstruents vs. full nasals (nasal consonant harmony of a different kind). In most Berber languages, sibilants within a certain domain assimilate in anteriority (coronal harmony) as well as in voicing (laryngeal harmony), often, but not always, resulting in complete identity. Hausa requires tautomorphemic homorganic stops to agree in [±constricted glottis] (laryngeal harmony); conversely, it also requires two tautomorphemic [+constricted glottis] stops to be completely identical—that is, to agree in both place and voicing as well. In cases such as these, an adequate phonological analysis must of course account for all of the harmony effects at once, unifying them by extracting common denominators to the extent that this is feasible. At the risk of obscuring such language-internal connections, cases which involve agreement in different types of features at once have been classified as separate instances of consonant harmony in the database.

Finally, it should be emphasized that the main goal is to explore the typology of consonant harmony *systems*. For this reason, reported instances of sporadic historical sound changes fitting the definition in (3) were not searched for. (Recall, for example, the interpretation of such examples by Jespersen 1904, 1922 as cases of 'consonant harmonization', as discussed in §1.2.1.) Such sporadic cases are no doubt due to the same phonetic and/or cognitive factors as genuinely systematic phonological patterns, and might even constitute the 'seeds' of more pervasive consonant harmony. However, a thorough and methodical search for such diachronic cases would have extended the scope of the present study beyond manageability. A few instances of historical sound changes which turned up during work on the survey have nevertheless been incorporated into the database; however, a language was only included if it shows evidence of such 'harmonizing' changes in several words (half a dozen or more) rather than just one or two cases. The languages in question are Russian (Kochetov & Radišić 2008) and certain Formosan languages (Paiwan, Saisiyat, Thao) discussed by Blust (1995); all are discussed briefly in §2.4.1.1. In the Formosan languages, the pervasive and recurrent sound changes in question are of interest in that they show the participation of lateral [ɬ] (in Thao) in what otherwise looks like a typical example of sibilant harmony; in better known cases like Navajo or Tahltan, laterals like [ɬ] or [tɬ] are consistently neutral and transparent to coronal harmony.

2.3. Root-Internal Harmony: The Status of Morpheme Structure Constraints

In determining what kinds of phenomena to include in the database, the important methodological decision was made that 'static' co-occurrence restrictions (morpheme structure constraints, MSCs) should be counted, as long as these were assimilatory in nature, prohibiting disagreement in some feature. In previous literature on consonant harmony, the cases reported have typically involved alternations which result from harmony operating across morpheme boundaries (as in Navajo [ʃì-tàːʔ] 'my father' vs. [sì-ts'àːʔ] 'my basket', the latter showing 1SgPoss /ʃi-/ → [si-] due to harmony). Although assimilatory co-occurrence restrictions are often mentioned in the general literature on MSCs (e.g. the discussion of Nilotic coronal harmony in Yip 1989), an explicit connection to consonant harmony in the more conventional sense is rarely made. The decision to include 'static' co-occurrence restrictions (MSCs) alongside 'dynamic' sound patterns (alternations) in this survey is motivated in part by formal considerations. There does not seem to be any principled foundation for stipulating that the two are different in kind, and the 'duplication problem' (Kenstowicz & Kisseberth 1977) arising from such a separation was one of the motivations for the shift to output-oriented and constraint-based models like Optimality Theory (see McCarthy 2002:71–76). Even 'dynamic' manifestations of consonant harmony are often confined to a specific morphologically defined domain (for example affecting derivational affixes closer to the root but not inflectional affixes further away). There is no *a priori* reason why harmony could not in some cases be confined to the smallest conceivable domain, namely the root.

Furthermore, the 'static' vs. 'dynamic' labels are rather misleading in that even morpheme-internal co-occurrence restrictions can give rise to overt alternations. This may occur, for example, when harmony interacts with ablaut-like stem alternations or 'mutations'. For example, many of the Western Nilotic languages display root-internal coronal harmony, a co-occurrence restriction on dental vs. alveolar obstruents and nasals, as illustrated by the Päri examples in (4). Note that the liquids /l, r/ are redundantly alveolar and freely co-occur with both series. (Morpheme-final '`' in the examples in (4)–(5) indicates a floating low tone.)

(4) Root-internal coronal harmony in Päri (Andersen 1988)

a. Well-formed roots with multiple (non-'palatal') coronals:

t̪ʊ̀ɔn̪	'male'
n̪ɔt̪	'sucking'
d̪á:n̪-ɛ̂	'person (ergative)'
àtwá:t`	'adult male elephant'
àdú:nd-ó̂	'heart'

b. Disallowed root-internal combinations:

*d̪…n	*d̪…nd	*d̪…t	*t̪…n	*t̪…nd	(etc.)
*d…n̪	*d…n̪d̪	*d…t̪	*t…n̪	*t…n̪d̪	(etc.)

c. Alveolar /l, r/ are neutral:

tìɛl	'legs'
-t̪ɔ̀:l`-ì	'ropes'
rʊ̀:t	'grind'
rwʌ̀t̪	'chief'

Independently of this assimilatory MSC, Western Nilotic languages make extensive use of root-final consonant mutations in their derivational and inflectional morphology (see Andersen 1988, 1999, Tucker 1994, Reh 1996). Among the patterns observed, a root-final /l/ may change to [t] or [nd], and vowel-final roots may have alternate realizations with final [n(:)]. This is illustrated for Päri in (5). In those cases where such alternations would be expected to yield a disharmonic dental…alveolar sequence, coronal harmony is enforced, and the root-final consonant instead surfaces as dental [n̪], [n̪d̪], and so forth.

(5) Consonant mutations feed root-internal harmony in Päri (Andersen 1988)

a.

Completive 3Sg	*Completive 3Pl*	
á-gɔ̀:l-é	á-gɔ̀:nd-é	'he/they scratched it'
á-tɛ̀:l-ɛ́	á-tɛ̀:nd-ɛ́	'he/they pulled it'
á-t̪á:l`-ɛ́	á-t̪á:n̪d̪`-ɛ́	'he/they cooked it'

b.

Unpossessed	*Possessed (1Sg)*	
bɔ̀:l-ì	bɔ̀:t-â	'(my) handles'
àbí-í`	àbí:n`-á	'(my) cloth'
dè:l	dè:nd-á	'(my) skin'
tà-à	tà:n:-á	'(my) pancreas'
t̪ùol	t̪úon̪d̪-à	'(my) snake'
ùt̪ó`-ó	ùt̪ó:n̪`-á	'(my) fox'

In fact, a great number of the consonant harmony cases included in this survey are restricted to the root domain. Treating these as equivalent to more 'dynamic' cases brings to light a curious typological difference between vowel and consonant harmony. Vowel harmony frequently applies exclusively (or primarily) in derived contexts, operating across morpheme boundaries, with disharmony being rampant within roots. In consonant harmony systems, on the other hand, roots are rarely exceptional in this manner; indeed, the root is very often the only domain where harmony applies and is enforced. Some of the types of consonant harmony surveyed here are almost exclusively attested as root-internal co-occurrence restrictions (laryngeal harmony, for example). But even for something as canonical as sibilant harmony, a considerable number of the attested cases involve MSCs.

A final argument for equating root-internal co-occurrence patterns with harmony alternations in heteromorphemic contexts comes from the comparative-historical domain. In situations where some kind of consonant harmony is attested in several related languages, one frequently finds that some of the languages restrict the harmony to the root domain while in others it extends to affixes. Returning to Western Nilotic coronal harmony, we find that in many of the languages it is strictly root-internal (Päri, Adhola, Alur, Anywa, Luo, Shilluk), but in at least one language, Mayak, suffixes also harmonize with the preceding root (Andersen 1999). Another example is sibilant harmony in the Omotic languages, where root-internal harmony can be reconstructed already for Proto-Omotic (Hayward 1988). Whereas most daughter languages show little or no trace of sibilant harmony reaching beyond the root, several have extended it to suffixes, resulting in alternations (Aari, Benchnon, Koyra, Maale, Zayse). In Zayse, harmony in suffixes is merely optional (Hayward 1990b). According to Hayward (1988:297 n. 38), optionality of harmony is particularly characteristic of inflectional suffixes, both in Koyra and in Aari. In Benchnon, certain suffixes undergo harmony but not others (for example, out of the two causative suffixes /-s/ and /-as/, only the former harmonizes).

To sum up, one of the claims implicit in the design of this survey is that the distinction between 'static' assimilatory MSCs and 'dynamic' (alternation-yielding) harmony processes is epiphenomenal. Rather than reflecting a fundamental difference in the nature of the sound patterns involved, that distinction merely translates into a difference in the size and scope of the morphological domain within which harmony is enforced.[2]

2.4. Classification by Harmonizing Property

This section, which spans the remainder of this chapter (close to 100 pages) presents a detailed overview of the range of consonant harmony cases contained in the survey database. These are classified by the category of consonants involved and by the phonetic-phonological properties that define the harmony. Each type and subtype is illustrated with several examples; this is true in particular of the less familiar harmony types. Needless to say, space does not permit all of the systems in the database to be illustrated, though nearly all of them are at

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[2] The sensitivity of consonant harmony to morphological domains is dealt with briefly in §5.3.1 below.

least mentioned briefly. An attempt has been made to include, for each type, examples of root-internal harmony as well as ones displaying harmony alternations (if any).

The classification scheme used here is primarily designed to serve expository purposes; it is quite possible that individual cases will upon closer inspection prove to belong in a category different from the one assigned here. One problem is the frequent lack of precise and unambiguous phonetic descriptions in the reference sources used. Given the size and scope of this survey, it was often not feasible to follow up by searching for other more detailed sources on the language in question. It is thus inevitable that a certain amount of relevant detail has been overlooked or misinterpreted in some way. Another recurring dilemma concerns the ambiguity inherent in much traditional descriptive-phonetic terminology. The terms 'palatal' and 'palatalized' are perhaps the most extreme example. Whereas 'palatalization' in the strict sense refers to the superimposition of an essentially vocalic articulatory gesture onto a consonant (yielding segments like [s^j], [m^j], etc.), the term is often used to refer to processes such as /s/ → [ʃ], /d/ → [dʒ] or /dz/ → [dʒ], and the resulting postalveolar fricatives or affricates are often labeled 'palatals'. Indeed, when a descriptive source refers to a 'palatal stop', perhaps rendering that segment semi-orthographically as 'j', it is often nearly impossible to determine whether the segment being referred to is truly a (dorso-)palatal stop [ɟ] or a lamino-postalveolar affricate [dʒ]. The descriptive terminology used for sibilants is even more confusing: a segment transcribed as 'š' or 'ʃ' may be described alternatively as 'alveo-palatal', 'palato-alveolar', 'blade-alveolar', 'groove-alveolar', 'lamino-palatal', 'dorso-palatal', or simply 'palatal', where it is far from clear exactly what the author means by the term being used. The problem is compounded when the source consulted is of a theoretical-analytical sort rather than a purely descriptive work, since phonological analysis usually presupposes an interpretation of the phonetic facts in terms of more abstract features or feature classes. For example, Humbert (1995) treats sibilant harmony in the Chumashan languages—which appears to have involved either an alveolar-postalveolar contrast ([s] vs. [ʃ]) or a laminal-apical contrast among alveolars ([s̻] vs. [s̺])—as 'secondary-articulation' harmony.

Keeping these caveats in mind, the consonant harmony systems attested in the survey database have been grouped into the following major categories. Coronal harmony (§2.4.1), by far the most commonly attested class, is here divided into sibilant harmony (§2.4.1.1) and the somewhat heterogeneous class of 'non-sibilant' coronal harmony systems (§2.4.1.2). Those rare cases which involve distinctions that are subordinate to major articulators other than [coronal] are discussed in a separate section on dorsal and labial consonant harmony (§2.4.2). Consonant harmony based on secondary articulations (pharyngealization, labialization, palatalization, etc.) is discussed in §2.4.3. Nasal consonant harmony, which involves long-distance assimilation in [±nasal] between consonants, without concomitant nasalization of intervening vowels, is treated in §2.4.4. Liquid harmony (§2.4.5) covers harmony between different kinds of liquids, for example in terms of the feature [±lateral], as well as between liquids and non-liquids (typically glides). An extremely rare but important phenomenon is what is here referred to as stricture harmony (§2.4.6), which involves manner distinctions such as fricative vs. stop, fricative vs. affricate, or stop vs. affricate. Consonant harmony based on laryngeal features (voicing, aspiration and glottalic vs. pulmonic airstream mechanism) is covered in §2.4.7. Finally, §2.4.8 re-examines the oft-repeated assertion that major-place consonant harmony does not exist in adult language (in contrast to child language, where it is rampant). As it turns out, a non-negligible number of attested sound patterns could potentially be characterized either as major-place consonant harmony or as an independent category of 'total' consonant harmony.

2.4.1. Coronal Harmony

Of all the different types of consonant harmony surveyed, one stands out as being exceptionally common in the world's languages. This is the class of phenomena conventionally known as coronal harmony. In this respect, the present survey confirms previous claims to the effect that coronal harmony is the *predominant* kind of consonant harmony (Shaw 1991), though it contradicts the stronger claim (Gafos 1999) that it is the *only* attested kind. The term 'coronal harmony' may seem self-explanatory, but it is worth clarifying briefly what is included under that rubric in this survey, especially since individual cases of other types of harmony often involve interactions between consonants that happen to be coronals (liquid harmony, stricture harmony, secondary-articulation harmony, laryngeal harmony).

As the term is used here, 'coronal harmony' refers to assimilatory interactions between coronals where the phonetic-phonological property in question is a coronal-specific 'minor place of articulation' specification of some kind, typically having to do with the configuration of the coronal articulator (the tongue tip and blade) or the constriction location, or both. Roughly speaking, the parameters involved are tongue posture (apical vs. laminal) and target region (dental vs. alveolar vs. postalveolar).[3] Coronal harmony systems are attested for various contrasts of this kind. Some examples are lamino-dental vs. alveolar ([t̻] vs. [t], [θ] vs. [s]), apico-alveolar vs. lamino-alveolar ([s̺] vs. [s]), alveolar vs. apico-postalveolar ([t] vs. [ʈ], [s] vs. [ʂ]), and alveolar vs. lamino-postalveolar ([t] vs. [tʃ], [s] vs. [ʃ]). Note that apico-postalveolar and lamino-postalveolar articulations are largely equivalent to the more traditional terms 'retroflex' and 'palato-alveolar', respectively (the latter sometimes also referred to as 'alveo(lo)-palatal' or simply 'palatal', especially in less phonetics-oriented works, as discussed above).

As for the potential relevance of manner distinctions ([±continuant] and the like), coronal harmony effects are attested for a wide range of segment types, including stops, affricates, fricatives, nasals and liquids. Nevertheless, the most frequently encountered kind of coronal

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[3] Gafos (1997, 1999) suggests that, at least in the case of fricative (or affricate) contrasts such as [θ] vs. [s] vs. [ʃ], the latter parameter should be reinterpreted as being a matter of the (cross-sectional) constriction *area*. As for languages with dental vs. alveolar stop contrasts, Gafos argues that the phonologically relevant parameter is the laminal vs. apical parameter distinction. To avoid confusion, the more traditional phonetic 'target region' terminology is used here (see Ladefoged & Maddieson 1996).

harmony is sibilant harmony, where the interacting segments are fricatives and/or affricates, primarily [+strident] ones. Because it is such a salient subtype of coronal harmony, sibilant harmony is here treated in a separate section (§2.4.1.1), followed by a section on coronal harmony systems where only non-sibilant coronals are involved (§2.4.1.2).

2.4.1.1. Sibilant Harmony

It is safe to say that the prototypical consonant harmony is one in which the interacting segments are sets of contrasting sibilants, such as alveolar [ts, s, z] vs. (lamino-)postalveolar [tʃ, ʃ, ʒ]. In fact, it would be more accurate to describe *sibilant* harmony in particular, rather than coronal harmony in general, as predominant type of consonant harmony. Indeed, *non*-sibilant coronal harmony systems (§2.4.1.2) are about as rare as little-known types such as dorsal harmony or liquid harmony. Sibilant harmony systems, by contrast, constitute about one-third of all the entries in the survey database. The languages in question belong to almost 20 different genetic groupings and are distributed over five continents (Africa, Asia Europe, and North and South America).[4]

The most common kind of sibilant harmony is based on the alveolar vs. lamino-postalveolar distinction: [s, z, ts, dz] vs. [ʃ, ʒ, tʃ, dʒ]. (The latter will henceforth be referred to simply as 'postalveolars' even though, strictly speaking, that term also covers retroflexes.) The prevalence of this type of harmony is no doubt due to the fact that the alveolar/postalveolar distinction appears to be the cross-linguistically most frequent type of sibilant contrast. One of the best-known examples of consonant harmony, **Navajo** sibilant harmony, is of exactly this kind (Sapir & Hoijer 1967, Kari 1976, Halle & Vergnaud 1981, McDonough 1990, 1991, 2003, Faltz 1998, Martin 2004, 2007). As was illustrated briefly in §1.1, sibilant harmony in Navajo involves the two contrasting sibilant series /ts, ts', dz, s, z/ and /tʃ, tʃ', dʒ, ʃ, ʒ/. It applies in a right-to-left fashion (with certain exceptions, to be discussed in §3.1.2) throughout a domain comprising the verb stem and so-called 'conjunct' prefixes, as well as between a noun and a possessive prefix. A sibilant in the root thus triggers assimilation in prefix sibilants (6a), and these in turn trigger assimilation in any prefix sibilants preceding them (6b–c).[5]

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[4] The geographic distribution of sibilant harmony is necessarily limited by certain areal-typological trends in segment inventories. For example, most aboriginal languages of Australia and New Guinea lack fricatives altogether, or have only /s/, and a great number of Austronesian languages also have no more than one sibilant.

[5] The interaction of Navajo sibilant harmony with morphological constituency relations is further discussed in §3.1.2 below.

(6) Navajo: sibilant harmony (data from McDonough 1991)

a.	jismas	/j-iʃ-mas/	'I'm rolling along'
	ʃidʒéːʔ	/si-dʒéːʔ/	'they lie (slender stiff objects)'
b.	sisná	/ʃ-is-ná/	'he carried me'
	dʒiʃtaːl	/dz-iʃ-l-taːl/	'I kick him [below the belt]'
c.	dzists'in	/dz-iʃ-l-ts'in/	'I hit him [below the belt]'

The same kind of sibilant harmony is found elsewhere in the Apachean (Southern) group of Athapaskan languages, e.g., **Chiricahua Apache** (Hoijer 1939, 1946), **Western Apache** (de Reuse & Goode 2006) and **Plains Apache** (**Kiowa Apache**; Bittle 1963). In the Northern branch of the Athapaskan family, consonant harmony involving alveolar and postalveolar sibilants is also attested in **Tahltan** (Hardwick 1984, Nater 1989, Shaw 1991), the Doig River dialect of **Dane-zaa** (**Beaver**; Story 1989), **Tsuut'ina** (**Sarcee**; Cook 1979, 1984), the Bearlake dialect of **Dene-tha** (**Slave**; Rice 1989) and **Lower Tanana** (Tuttle 1998). In the third branch of the Athapaskan family, the Pacific Coast subgroup, some sibilant harmony of the same type has been reported for **Tututni** (Golla 1976) and **Hupa** (Golla 1970), though this occurs only in very restricted morphological contexts.[6] Moreover, sibilant harmony can be reconstructed, as a root-internal co-occurrence restriction, as far back as **Proto-Athapaskan-Eyak** (Krauss 1964), where (cross-series) combinations of segments from the *ts, *tʃ and *tʃʷ sibilant series did not occur within a morpheme.[7]

Sibilant harmony of the alveolar vs. postalveolar type is found in many other aboriginal languages of North America. Another well-known case is that found in several of the Chumashan languages (Yu 2000b), such as **Ineseño** (Applegate 1972), **Barbareño** (Beeler 1970, Mithun 1998) and **Ventureño** (Harrington 1974, Mamet 2005). Chumash sibilant harmony has figured prominently in generative analyses of consonant harmony (Poser 1982, 1993, 2004, Lieber 1987, Steriade 1987, Shaw 1991, McCarthy 2006). It should be noted, however, that it is far from clear whether the sibilant distinctions involved were primarily a matter of

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[6] Outside of the root, harmony in Hupa seems to affect only the human deictic subject prefix /tʃ'ɪ-/, when this immediately precedes an /s/ (usually belonging to the /s-/ perfective prefix), thus /tʃ'ɪ-s-tatʃ'/ 'he tattooed [someone]' → [ts'ɪstatʃ']. In Tututni, harmony appears to affect only the combination of the conjugation marker /sə-/ and 1SgSubj prefix /ʃ-/, and only in so-called neuter verb themes (resulting in /sə-ʃ-/ → [sə-s-]; see §3.1.2 for a similar phenomenon in Navajo). In Tututni, adjacent sibilants also assimilate, but this local assimilation might well be distinct from the sibilant harmony across an intervening vowel.

[7] Note also that the peculiar sibilant *pharyngealization* harmony found in **Tsilhqot'in** (**Chilcotin**; Krauss 1975, Cook 1983, 1987, 1993, Hansson 2007c), described in §2.4.3 below, is cognate with the coronal harmony found in Navajo, Tahltan, etc., and developed out of what was originally a more conventional coronal harmony of the kind described here (see Hansson 2007c for details).

alveolar vs. postalveolar ([s] vs. [ʃ], etc.) or, alternatively, laminal vs. apical ([s] vs. [s̺], etc.); sibilant harmony systems of the latter kind will be discussed later in this section.

Just like its Athapaskan counterpart, Chumash sibilant harmony is anticipatory: the rightmost sibilant in a word determines the realization of all preceding sibilants. This is illustrated by the Ineseño examples in (7a–b). Because of the exclusively prefixing character of Athapaskan morphology, the right-to-left directionality of sibilant harmony in languages like Navajo or Tahltan goes hand in hand with morphological constituent structure—in other words, harmony applies in an 'inside-out' fashion from stem to affix (though see §3.1.2 for qualifications). However, the same is not true of Chumash sibilant harmony, where the right-to-left directionality is clearly independent of morphological structure (Poser 1982). As examples such as those in (7b) show, suffixes will trigger harmony in a preceding root (as well as in earlier prefixes), resulting in an 'outside-in' effect. See §4.3.1 for a formal analysis of the absolute right-to-left directionality in Chumash sibilant harmony.

(7) Ineseño (Chumash): sibilant harmony (data from Applegate 1972)

a. Unbounded right-to-left harmony (causative /su-/; 3Subj /s-/)

kʃuʃojin	/k-su-ʃojin/	'I darken it'
ʃapitʃ^{h}olit	/s-api-tʃ^{h}o-it/	'I have a stroke of good luck'

b. Directionality independent of morphology (past /-waʃ/; 3Obj /-us/)

sapits^{h}olus	/s-api-tʃ^{h}o-us/	'he has a stroke of good luck'
ʃapitʃ^{h}oluʃwaʃ	/s-api-tʃ^{h}o-us-waʃ/	'he had a stroke of good luck'
haʃxintilawaʃ	/ha-s-xintila-waʃ/	'his former Indian name'
sistisijepus	/s-iʃ-tiʃi-jep-us/	'they (two) show him'

c. Harmony overridden (and fed) by precoronal /s/ → [ʃ] change

ʃtijepus	/s-ti-jep-us/	'he tells him'
ʃiʃlusisin	/s-iʃ-lu-sisin/	'they (two) are gone awry'
ʃiʃtiʔɨ	/s-is-tiʔ/	'he finds it'

The disharmonic forms in (7c) illustrate the interaction of sibilant harmony with an independent constraint causing /s/ → [ʃ], etc., before the nonsibilant coronals /t, l, n/ (Poser 1982, 1993, McCarthy 2006). This precoronal effect, which McCarthy (2006) interprets as an OCP-driven dissimilation in [±anterior], is restricted to derived environments (i.e. heteromorphemic clusters, cf. tautomorphemic /wastu/ → [wastu] 'pleat'). It overrides sibilant harmony, in that the resulting sibilants are consistently postalveolar, regardless of the quality of any following sibilants in the word.[8] As shown by the last example in (7c), the precoronal effect

[8] Notice that even an underlying /ʃ/ can be disharmonic in this way (cf. the second example in 7c), as long as it is in a heteromorphemic [ʃt], [ʃl] or [ʃn] cluster. The generalization that precoronal [ʃ] is immune to sibilant harmony is not without exceptions in Ineseño; it does occasionally undergo harmony (cf. the last example in 7b), just like in tautomorphemic sibilant +

simultaneously *feeds* sibilant harmony, in that the [ʃ] in question will itself trigger harmony on any preceding sibilants.

Mithun (1998) characterizes the historical sound change responsible for the precoronal effect as having been a matter of *apicalization* before (apical) /t/, /n/, etc.; in other words, an allophonic process /s/ → [s̺] or [s̺̠], rather than a neutralizing process /s/ → [ʃ] (causing a merger with phonemic /ʃ/). Mithun does not discuss the interaction of this allophonic apicalization with sibilant harmony—namely the fact that the (allegedly) apical allophone of /s/ has come to trigger the same kind of harmony as postalveolar /ʃ/ does. One possible diachronic scenario is that the [s̺] (or [s̺̠]) allophone subsequently merged with /ʃ/, giving rise to surface exceptions to sibilant harmony, and that sibilant harmony was then enforced in any preceding prefixes. The historical aspects of the interplay of apicalization and sibilant harmony certainly merit further investigation. A preliminary analysis of the interaction of sibilant harmony with the precoronal effect in Ineseño is presented in §5.1.1 below (see McCarthy 2006 for a fuller analysis along similar lines).

In addition to the various Athapaskan and Chumashan languages mentioned thus far, harmony between what appear to be alveolar and (lamino-)postalveolar sibilant series is also found in many other native languages of the Americas. The ones spoken in North and Central America are at least the following: **Southern Paiute** (Uto-Aztecan; Sapir 1931, Harms 1966, Lovins 1972); **Wiyot** (Algic; Teeter 1959, 1964); **Rumsen** (Costanoan; Garrett 1999, based on Miller 1999); various Mayan languages, such as **Tzeltal** (Kaufman 1971), **Tzotzil** (Cowan 1969), **Tzutujil** (Dayley 1985), classical and modern **Yucatec** (Straight 1976, Lombardi 1990, Noguchi 2007), **Ixil** (Nebaj dialect; Ayres 1991), and **Chol** (Gallagher 2008, Gallagher & Coon 2009); Totonacan languages, including **Misantla Totonac** (MacKay 1999) and **Tepehua** (Tlachichilco dialect; Watters 1988). In South America, this type of sibilant harmony is found at least in **Capanahua** (Panoan; Loos 1969) and some of the Quechuan languages, such as **Wanka Quechua** (Cerrón-Palomino 1967, 1977, Mannheim 1988) and **Southern Peruvian Quechua** (as spoken in the colonial period; Mannheim 1988, 1991). In virtually all of these languages, the harmony either exhibits right-to-left directionality or is manifested merely as a root MSC. The sole examples involving left-to-right directionality are Wiyot and Rumsen; here, the directionality may be attributed to morphological constituent structure (though this is less clear in the case of Wiyot).[9]

{t, l, n} clusters. In the closely related Ventureño, on the other hand, Harrington (1974) describes derived [ʃ] as being consistently unaffected by sibilant harmony.

[9] As noted in §1.2.1, Wiyot is unusual in that it displays a combination of sibilant (fricative) harmony, yielding /s/ → [ʃ], and liquid harmony, yielding /l/ → [r]. Neither is remarkable in and of itself, but Wiyot combines the two, in that /r/ also triggers /s/ → [ʃ], and /ʃ/ also triggers /l/ → [r]. This is possibly connected to the fact that Wiyot also has a systematic pattern of diminutive/augmentative consonant symbolism, whereby /s/ → [ʃ], /l/ → [r] and /t/ → [tʃ] or [ts] (see §6.3.3 for relevant discussion). It is also conceivable that the sibilant rendered here as

A somewhat special case is the mixed language **Michif** (Bakker 1996, Bakker & Papen 1996). The French component of Michif displays regressive sibilant harmony (/ʃɛʃ/ 'dry' < Fr. /sɛʃ/, /ʃavaːʒ/ 'Indian' < Fr. /sovaʒ/ 'savage, wild', /saːsiː/ 'window' < Fr. /ʃasi/ 'frame'). However, this state of affairs appears to be inherited wholesale from the **Métis French** dialect that entered into the French-Cree mixture which eventually became the Michif language (Papen 1984, Douaud 1985, Bakker & Papen 1996). For example, Métis French has /sɛz/ < /ʃɛz/ 'chair' and /ʃavaʒ/ ~ /savaz/ < /sovaʒ/ 'Indian; savage'. Sibilant harmony in Métis French was, in turn, almost certainly due to substratum influence from Plains Cree and/or Ojibwe, which lack any distinction between anterior and posterior sibilants. The same kind of sibilant harmony is described for **Bungee English**, a Cree-influenced dialect spoken by descendants of mixed Scottish-Cree couples in Manitoba (Blain 1989).[10]

Outside of the Americas, sibilant harmony involving the alveolar-postalveolar distinction is also described for a number of African languages, belonging to various branches of the Niger-Congo and Afro-Asiatic macro-families. Among Niger-Congo languages, for example, this kind of sibilant harmony has been described for the Plateau language **Izere** (Afuzare, Zarek; Blench 2001) and, within the Bantu family, for **Shambaa** (Kishambaa, Shambala; Roehl 1911) and several languages of the Lacustrine ('Zone J') subgroup, notably **Rwanda** (Kinyarwanda; Kimenyi 1979; Coupez 1980), **Rundi** (Kirundi; Meeussen 1959, Ntihirageza 1993) and **Nkore-Kiga** (Runyankore-Rukiga; Hyman 1999b, based on Taylor 1959). In all of these cases, harmony is manifested in alternations in roots and/or affixes. In Izere (Blench 2001), a /-s-/ pluractional (or habitual) infix, which often overwrites part of the root to which it attaches, harmonizes with a sibilant in the root: /sɔnɔŋ/ + /-s-/ → [sɔ́-s̱-ɔ̀ŋ] 'to insert (pl.)', but /ʃínìŋ/ + /-s-/ → [ʃí-ʃ̱-ìŋ] 'to fill up (pl.)', /tʃánàŋ/ + /-s-/ → [tʃá-ʃ̱-àŋ] 'defeat in wrestling; argument (pl.)'.[11] In all of the other languages, the directionality is uniformly right-to-left, often from suffix to root like in the Ineseño Chumash example above. It should also be noted that although the abovementioned sources on Rwanda describe the interacting sibilant

/ʃ/ ('š') is *apico*-alveolar, or perhaps even retroflex ([ʂ]), such that /ʃ, r/ do form a phonetically natural class in Wiyot.

[10] It appears that sibilant harmony is also a feature of **Papua New Guinean English**, judging by the following examples mentioned by Crowley (1997:58): [ˈʃoʊʃəl] *social* (cf. [səˈsaɪəti] *society*), [tækˈʃeɪʃən] *taxation*, [dəˈʃɪʒən] *decision*. Substratum influence is likely a factor here as well.

[11] The morphology of Izere pluractional formation is quite complex, and is subject to some highly unusual templatic constraints on place of articulation (see Hyman 2006 for details). In the present context, what is important is simply that whenever an /s/ gets affixed (suffixed or infixed, potentially overwriting some root consonant), it always harmonizes with a /ʃ/ or /tʃ/ elsewhere in the word. Other examples illustrating sibilant harmony in Izere pluractional formation are [ʃɛ́ːr] 'to hang up' vs. plur. [ʃɛ́ʃɛ̀k], [tʃér] 'to carry' vs. plur. [tʃéʃɛ̀k] (cf. [reːr] 'to cook' vs. plur. [résék], [tár] 'to shout; yell' vs. plur. [tásàk]), as well as [ʃán] 'to buy, receive' vs. plur. [ʃâːʃ] (cf. [gaŋ] 'to push' vs. plur. [gáːs]).

series as alveolar vs. lamino-postalveolar (/s, z/ vs. /ʃ, ʒ/), recent acoustic and articulatory studies of Rwanda sibilant harmony (Mpiranya & Walker 2005, Walker & Mpiranya 2005, Walker et al. 2008) show that the postalveolar series is in fact *retroflex*, i.e. apico-postalveolar, such that the contrast is in fact /s, z/ vs. /s̺, z̺/. This raises the question whether the other Lacustrine Bantu sibilant harmony systems (Rundi, Nkore-Kiga) have been similarly misclassified—a topic which awaits further phonetic research.

Within Afro-Asiatic, sibilant harmony is independently attested in at least four branches. In **Coptic**, several dialects (Sahidic, Akhmimic, Assiutic) underwent a sound change whereby /s/ > /ʃ/ in assimilation to a tautomorphemic /ʃ, tʃ/ (Chaine 1933, Till 1961, Westendorf 1977). There is much variation as regards directionality and the effects of trigger-target proximity within the word; however, the harmony seems to have been confined to the root domain. In these dialects, sibilant harmony is not triggered by those instances of /ʃ/ which are of secondary historical origin (reflecting earlier /x/, by a sound change which likely postdated the sound change of sibilant harmony). By contrast, in certain other dialects (Bohairic, Fayyoumic), harmony is almost exclusively triggered by this secondary /ʃ/ (< /x/), though descriptions are admittedly sketchy on this point.

The same kind of sibilant harmony is attested in various languages of the Berber subgroup of Afro-Asiatic; the directionality in all these cases is consistently right-to-left, from root to prefix. In the Northern Berber branch, sibilant harmony is found at least in Central Moroccan **Tamazight** (Ntifa dialect, Laoust 1918; Ayt Ndhir dialect, Penchoen 1973; cf. also Willms 1972) and in **Tashlhiyt** (Imdlawn dialect, Elmedlaoui 1995a [1992]; Agadir dialect, Lahrouchi 2003, 2005), where it manifests itself both root-internally and across morpheme boundaries. For example, the causative prefix /s-/ is realized as [ʃ-] or [ʒ-] in Tashlhiyt whenever the following root contains /ʃ, ʒ/, as in [s-mijːəl] 'to tilt' vs. [ʃ-fərːəʒ] caus. of 'amuse' (data from Lahrouchi 2005). The same kind of harmony is found in the **Tuareg** dialects (Tamajaq, Tamashek, etc.) that make up the Southern Berber branch (Alojaly 1980, Sudlow 2001, Heath 2005).[12]

A nearly identical harmony pattern is found in various Arabic vernaculars of North Africa, most notably **Moroccan Arabic** (Harris 1944, Harrell 1962, Heath 1987, 2002) and also **Libyan Arabic** (Abumdas 1985). Even though Arabic belongs to a different branch of the Afro-Asiatic family (Semitic), the sibilant harmony of these varieties is almost certainly areally (and sociolinguistically) connected to its Berber counterpart through language contact. Though the harmony is generally right-to-left, it also shows show some characteristics of a 'dominant-recessive' system, at least in certain dialects of Moroccan Arabic, with [–anterior] /ʃ, ʒ/ as the dominant class (see §3.1.2 below).

In the Chadic subgroup of Afro-Asiatic, sibilant harmony appears to be attested in a more subtle and perhaps not quite conclusive form. In **Bole** (Schuh 2002), alveolar /s, z/ and their

[12] The harmony interactions between sibilants in these Berber languages also involve long-distance *voicing* assimilation (i.e. laryngeal harmony; §2.4.7); see §3.2.2.2 below for detailed discussion.

postalveolar counterparts /ʃ, dʒ/ do not co-occur within a word ([tʃ] occurs as an allophone of /ʃ/). Moreover, a great many words in Bole display free variation—both inter- and intradialectal—between /s/ and /ʃ/ ([ʃ]/[tʃ]) and between /z/ and /dʒ/. When a word contains more than one sibilant, the co-occurring sibilants must co-vary, such that either all are alveolar or all are postalveolar (Schuh 2002, Riggle & Wilson 2004), as a consequence of sibilant harmony, for example in /sìnsor/ ~ /ʃìnʃor/ 'dew', /zànza/ ~ /dʒàndʒa/ 'star' and /sansala/ ~ /ʃanʃala/ 'pumpkin'. Elsewhere in Chadic, putative effects of sibilant harmony are intimately bound up with 'morphological palatalization', featural affixation processes whereby one or more segments in the base are 'palatalized' (resulting in changes like /s/ → [ʃ], /n/ → [ɲ], /b/ → [b^j], and sometimes the fronting of vowels). In those cases where such 'palatalization' typically targets a single base consonant, the relevant languages often display a clear preference for certain types of targets over others (Hoskison 1974, 1975, Schuh 2002, Ettlinger 2004). If an alveolar sibilant is present, it is usually the first choice, such that /s, z, ts, dz/ → [ʃ, ʒ, tʃ, dʒ]. In **Gude**, Hoskison (1974, 1975) describes morphological palatalization as targeting *all* such sibilants in the base, if any are present; if the base contains no sibilants, palatalization obligatorily targets only *one* consonant (additional consonants are optionally subject to palatalization as well).[13] This suggests that the featural affixation may be interacting with (i.e. feeding) an independent (and perhaps largely latent) sibilant harmony requirement. In this respect, morphological palatalization in **Miya** (Schuh 1998, 2002) works in the same way, obligatorily affecting *all* sibilants (/s, z, ts, dz/) in the base but only *one* non-sibilant consonant (if no sibilant is present; other than that, non-sibilants are palatalized optionally); vowels are often affected (fronted) as well, but with considerable variability. A similar but rather less conclusive case is presented by **Mafa** (Barreteau & Le Bleis 1990, Ettlinger 2004), where morphological palatalization obligatorily targets all sibilants (again, /s, z, ts, dz/), but also fronts all vowels (except when such fronting is blocked by phonotactic restrictions).

Finally, as mentioned in §2.3 above, sibilant harmony is quite widespread in the Omotic subgroup of Afro-Asiatic languages, spoken in southern Ethiopia. These include **Aari** (Hayward 1990a), **Benchnon** (Gimira; Breeze 1990, Rapold 2006), **Dime** (Seyoum 2008), **Koyra** (Koorete; Hayward 1982), **Maale** (Amha 2001) and **Zayse** (Hayward 1990b). Hayward (1988) discusses the historical development of sibilants across the Omotic languages, and reconstructs root-internal sibilant harmony for **Proto-Omotic**. In all of the daughter languages that retain sibilant harmony, it involves at least the alveolar vs. lamino-postalveolar series /ts, ts', s, z/ vs. /tʃ, tʃ', ʃ, ʒ/. Omotic sibilant harmony frequently yields alternations in affix sibilants, whereby /s, z/ → [ʃ, ʒ]. This is illustrated for Koyra in (8).

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[13] Hoskison (1974, 1975) includes /ɗ/ and /n/ in the same category as /s, z, ts, dz/ (i.e. as being subject to obligatory palatalization, but the data he cites are unfortunately too limited to verify the finer aspects of his classification of potential target consonants. Based on an extensive English-Gude wordlist (Schuh n.d.), Tsang (2007) finds little to support the designation of /ɗ, n/ as obligatory targets of palatalization.

(8) Koyra: sibilant harmony (data from Hayward 1982)

a. Root-internal harmony

Well-formed roots		*Disallowed sequences*	
suːts’-	‘blood’	*s…ʃ	*ʃ…s
zuːs-	‘creeper’	*s…tʃ	*tʃ…s
ts’ugunts-	‘fingernail’	*s…dʒ	*dʒ…s
ʃoːʃ-	‘snake’	*ts…ʃ	*ʃ…ts
dʒaʃ-	‘fear’	(etc.)	
ʔitʃːítʃːe	‘five’		

b. Harmony in affixes (caus. /-(u)s/, 3mSg.perf. /-osːo/, 3mSg.juss. /-esːe/)

dʒaʃ-uʃ-	‘cause to fear’
goːtʃ-uʃ-	‘cause to pull’
ʔordʒ-uʃ-	‘make big, increase (tr.)’
ʃaj-ʃ-	‘cause to urinate’
patʃː-oʃːo	‘it became less’
ʔordʒ-oʃːo	‘he/they got big’
giːʒː-oʃːo	‘it suppurated’
dʒaʃ-uʃ-eʃːe	‘let him/them frighten (s.o.)!’

c. Harmony is strictly transvocalic; no harmony at greater distances

ʃod-us-	‘cause to uproot’	(*ʃod-uʃ-)
ʃoh-us-	‘wash (tr.)’	(*ʃoh-uʃ-)
tʃ’aːn-us-	‘cause to load’	(*tʃ’aːn-uʃ-)
ʃodː-osːo	‘he uprooted’	(*ʃodː-oʃːo)
ʔatʃ-utː-osːo	‘he (polite) reaped’	(*ʔatʃutː-oʃːo)

In Koyra sibilant harmony, the trigger and target sibilants may at most be separated by a vowel (Hayward 1982, Ford 1990), and the same is true in Zayse as well (Hayward 1990b). The /ʃaj-(u)s-/ → [ʃaj-ʃ-] example in (8b) suggests that an additional (off-)glide may intervene as well. In Aari, Benchnon and Dime, on the other hand, there does not appear to be a limit on the distance between the trigger and target sibilants (Hayward 1988, 1990a, Breeze 1990, Seyoum 2008), as shown for Aari in (9).[14]

[14] While Seyoum (2008) makes no explicit mention of sibilant harmony in Dime, it can be inferred from many examples cited, such as /wutʃ-is-is-i-n/ → [wutʃiʃiʃin] ‘he made [someone] dry it’ and /RED-ʃub-is-á/ → [ʃuʃubiʃá] ‘remove moisture’ (both with causative /-is/), or /ʔandʒ-is/ → [ʔaɲdʒ-iʒ] ‘blessing’ (with definite marker /-is/). The last of these examples illustrates a separate process of long-distance voicing assimilation (laryngeal harmony; see §2.4.7 below).

(9) Aari: unbounded sibilant harmony (data from Hayward 1988, 1990a)

a. Harmony in causative /-sis/)

na̤ʃ-ʃiʃ-	'cause to love'
ʔuʃ-ʃiʃ-	'cause to cook'
qa̤ʒ-ʒiʃ-	'make cold'
ʃaːn-ʃiʃ-	'cause to urinate'
ʒa̤q-ʃiʃ-	'cause to throw'
tʃ'a̤ːq-ʃiʃ-	'cause to swear (oath)'

b. Harmony in perfective /-s/

ʔuʃ-ʃ-it	'I cooked'
qa̤ʒ-ʒ-it	'I got cold'
tʃ'a̤ːq-ʃ-it	'I swore'
ʒaʔ-ʃ-it	'I arrived'
baʃ-er-ʃ-it	'I was overcome
ʃed-er-ʃ-it	'I was seen'
ʒa̤ːg-er-ʃ-e	'it was sewn'

Sibilant harmony in Koyra and Aari can be characterized as 'transvocalic' and 'unbounded', respectively. The exact same dichotomy is attested for at least one other harmony type: nasal consonant harmony in Bantu languages (see §2.4.4). There, as in the Omotic case, closely related languages display variations on the same pattern, differing only in whether harmony is also enforced when the trigger and target consonants are separated by more segmental material than just a vowel.

Although the directionality is clearly left-to-right in the Koyra and Aari cases shown above—and indeed in all sibilant harmony alternations in Omotic—there is reason to believe that this is an epiphenomenon of morphological constituent structure. The more appropriate generalization, instead, is that harmony applies 'inside-out', from base to affix. Note that all alternating suffixes have alveolar /s/, and the harmony effect is thus always /s/ → [ʃ]. Hayward (1988) notes that within roots, there is diachronic evidence suggesting that the harmony applied bidirectionally. In loanword adaptation, Amharic /t'/ is usually rendered with Zayse /ts'/; however, /tʃ'adʒːe/ 'mead' (from Amharic /t'ädʒː/) and /tʃ'iloːʃa/ 'brideprice' (from Amharic /t'ɨloʃ/) appear to have been subject to *right-to-left* sibilant harmony, given the otherwise expected */ts'adʒːe/, */ts'iloːʃa/.

Proto-Omotic had a third, retroflex (i.e. *apico*-postalveolar) series of sibilants *tʂ̻', *ʂ̻, *ʐ̻; these were also covered by the (root-internal) harmony, which thus ruled out the co-occurrence of alveolar, lamino-postalveolar and apico-postalveolar sibilants (Hayward 1988).

At least one of the daughter languages, Benchnon (Gimira), retains all three series. Here, as in Proto-Omotic, we see a three-way sibilant harmony; this is illustrated in (10).[15]

(10) Benchnon: three-way sibilant harmony (data from Hayward 1988)

a. Root-internal harmony

Well-formed roots		*Disallowed root sequences*
sis	'fir tree'	*s…ʃ, *s…ʂ, *ʃ…s, *ʃ…ʂ, etc.
zos	'neighbor'	*s…tʃ, *s…tʂ, *ʃ…ts, *ʃ…tʂ, etc.
ts'ots'-	'centre'	*ts…ʃ, *ts…ʂ, *tʃ…s, *tʃ…ʂ, etc.
ʃaʃkn	'green tree-snake'	*ts…tʃ, *ts…tʂ, *tʃ…ts, *tʃ…tʂ, etc.
tʃiʃkn	'bile'	*ts'…ʃ, *ts'…ʂ, *tʃ'…s, *tʃ'…ʂ, etc.
ʒatʃu	'maize flower'	*ts'…tʃ, *ts'…tʂ, *tʃ'…ts, *tʃ'…tʂ, etc.
ʂetʂ'	'type of cabbage'	*z…ʃ, *z…ʂ, *ʒ…s, *ʒ…ʂ, etc.
ʐeʐ-	'become red'	(etc.)
tʂ'ontʂ'-	'fill (tr.)'	

b. Harmony alternation ([s] ~ [ʃ] ~ [ʂ]) in causative /-s/

s^{j}ap-s-	'make wet'
ʃir-ʃ-	'bring near'
tʃ'ob-ʃ-	'make light'
ʂup-ʂ-	'make soft'

In fact, several of the languages mentioned earlier in this section have similar three-way harmony systems, involving not only alveolar and lamino-postalveolar ('palatal') sibilants but also a third series of apico-postalveolar ('retroflex') ones. These include Capanahua (Loos 1969) and the Nebaj dialect of Ixil (Ayres 1991), and possibly Proto-Athapaskan-Eyak as well (Krauss 1964).[16] The same is also true of Rumsen sibilant harmony (Garrett 1999, based on Miller 1999), but here the three series do not play an equal part in the harmony. Whereas alveolar /s, ts/ assimilate to apico-postalveolar /ʂ, tʂ/, and vice versa, the participation of lamino-postalveolar /ʃ, tʃ/ in the harmony is marginal; see §5.3.3 for further discussion. In the root-internal harmony found in Wanka Quechua (Cerrón-Palomino 1967, 1977), on the other hand, only retroflex and 'palatal' sibilants interact, whereas the alveolar /s/ does not partici-

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[15] The phonetic description and transcriptions of the three sibilant series of Benchnon here follows Hayward (1988) and Breeze (1990). Rapold (2006) instead classifies the 'retroflex' series as alveolo-palatal /ɕ, ʑ, cɕ, cɕ'/.

[16] Reconstructions of the Proto-Athapaskan consonant inventory vary as to whether the so-called *tʃ^w series sibilants were labialized, or perhaps a retroflex *ʈʂ series (as reflexes in some Northern Athapaskan languages suggest).

pate in the harmony.[17] In his description of the sibilant harmony in Benchnon (Gimira), seen in (10) above, Rapold (2006:67–69) describes a similar asymmetry. According to Rapold, a suffixal alveolar (/s/) will harmonize with a root sibilant of either of the other two series, but a suffixal lamino-postalveolar (/ʃ/) will yield only to a sibilant of the 'retroflex' series—which Rapold describes instead as alveolo-palatal (/ç/, etc.; see n. 15 above)—and an underlying alveolo-palatal/'retroflex' sibilant never undergoes harmony. (In addition, harmony applies only between a root and an immediately following suffix; there is no harmony interaction between suffix sibilants, cf. /nʲāʔ-ùç-īs/ → [nʲāʔùçīs], *[nʲāʔùçīç] 'that child'.)

In many of the sibilant harmony systems discussed so far, it is difficult to determine exactly the nature of the phonetic distinction between the harmonizing sibilant series. In some cases, it is quite possible that the relevant parameter is not so much alveolar vs. postalveolar, as has been assumed here, but rather a laminal vs. apical distinction ('tip-down' vs. 'tip-up', in gestural terms; Gafos 1999). One case in which it is quite clear that a pure apical/laminal opposition is involved is **Basque**, where sibilant harmony is a root-internal co-occurrence restriction (Hualde 1991, Trask 1997, Clements 2001). Basque sibilants exhibit a three-way contrast between apico-alveolar /s̺, ts̺/, lamino-alveolar /s, ts/, and lamino-postalveolar ('palatal') /ʃ, tʃ/ (represented in Basque orthography as <s, ts>, <z, tz> and <x, tx>, respectively). Bizkaian dialects, and some Gipuzkoan dialects, have merged the two alveolar series. According to Hualde (1991), sibilants drawn from any two of these three series do not co-occur within morphemes. Hualde bases his characterization of sibilant harmony on Salaburu's (1984) description of the High Navarrese dialect as spoken in Baztan; the latter claims that no counterexamples are found. If true, this means that Basque displays a three-way sibilant harmony, at least dialectally, similar to that found in Benchnon (Gimira), Ixil, Capanahua, and so forth. In all of these cases, harmony involves a (lamino-)alveolar series, a lamino-postalveolar one (/ʃ/, etc.) and a third, apical series. While this third series appears to be apico-*post*alveolar (retroflex) in Benchnon, Ixil, etc. (though see n. 15 above regarding Benchnon), it is apico-alveolar in Basque.

Other descriptions of Basque sibilant harmony (Michelena 1985, 1995, Trask 1997) make no mention of the postalveolar series being implicated. Instead, harmony is merely said to prohibit the co-occurrence of the apico-alveolar and lamino-alveolar series: /s̺, ts̺/ vs. /s, ts/. Indeed, forms combining 'palatal' sibilants with alveolar ones are attested, at least dialectally (e.g., /tʃimis̺ta/ 'lightning', /tʃos̺ten/ 'report'). The root-internal harmony between apical and laminal alveolars, on the other hand, is a very robust generalization which is clearly part of the Basque grammatical system. That harmony asserts itself actively, for example, in loanword adaptation (/fran(t)s̺es̺/ 'French' < /fran(t)ses/, from Spanish *francés*) and in the reanalysis of compounds as single morphemes (/s̺inets̺i/ 'believe' < /sin-ets̺i/, cf. /sin/ 'truth', /(h)ets̺i/ 'consider'; /es̺ets̺i/ 'persist' < /es/ 'no' + /(h)ets̺i/). In general, the directionality of

[17] Interestingly, the palatal sonorants /ʎ, ɲ/ appear to participate in the coronal harmony in Wanka Quechua, in that these never co-occur with the retroflex affricate /ts̺/ (Cerrón-Palomino 1977:62).

assimilation is right-to-left, but interestingly, the apical series tends to be the 'dominant' one. Left-to-right harmony is thus observed in /s̺ats̺uri/ 'mole' (17th century) < */s̺at-suri/ and in /s̺as̺oi(n)/ < */s̺asoi(n)/ (from Spanish *sazón*). Some dialects have right-to-left assimilation even in these words (Isaba /sasoi/, Vidángoz /sasoĩ/; Michelena 1985).

Aside from Basque, sibilant harmony appears to be fairly uncommon in the languages of Eurasia. Harmony involving /s, z/ vs. /ʃ, ʒ/ occurs in **Teralfene Flemish** (Willem de Reuse, pers. comm.), where the former assimilate to the latter (e.g. /kɑliʃə/ + /zɑp/ → [kɑˈliʃəʒɑp] 'licorice juice' and the personal names /ʒəʒɛf/ *Joseph* and /ʒəʒeː/ *Josée*, with /ʒ…ʒ/ in place of standard /ʒ…z/). Also, though it does not qualify as a case of systematic consonant harmony, **Russian** deserves passing mention here as well. In the context of their experimental study of elicited speech errors in Russian, Kochetov & Radišić (2008) note a considerable number of cases of sibilant 'harmonization' in historical sound changes, loanword adaptations, and dialectal developments (cf. the discussion in §1.2.1 above). All of these involve an anterior sibilant /s/ assimilating to a nearby—usually following, but occasionally preceding—posterior sibilant /ʃ/ or /tʃ/, such as in /ʃerʃenʲ/ 'hornet' (< Old Russian /sĭrʃenĭ/), /ʃubaʃ/ 'head of police' (from Turkic /subaʃɨ/) or the dialectal /ʃmortʃok/ 'shorty' (alongside Standard Russian /smortʃok/).

The Indo-Aryan language **Kalasha** (Arsenault & Kochetov 2008, 2009) displays a three-way root-internal coronal harmony which encompasses sibilants (fricatives and affricates) as well as nonsibilant coronal stops (cf. §2.4.1.2). Kalasha coronals form three series, all of which participate in the harmony: 'dental' /s, z, ts, tsʰ, dz, t, tʰ, d, dʰ/, retroflex /ʂ, ʐ, ʈʂ, ʈʂʰ, ɖʐ, ʈ, ʈʰ, ɖ, ɖʰ/ and alveolo-palatal /ʑ, ɕ, tɕ, tɕʰ, dʑ, dʑʰ/. In Kalasha roots, harmony is evident in pairs of co-occurring coronal obstruents that have the same manner of articulation (fricative…fricative, affricate…affricate, stop…stop).[18] In such pairs, retroflexes never co-occur with non-retroflexes, and alveolars co-occur with alveolo-palatals only very rarely. Different-manner pairs, on the other hand, are not restricted in any such way. Arsenault & Kochetov (2008) also report some historical data bearing on the enforcement of harmony (e.g. /ɕiɕoa/ 'handsome' < *suɕoːbʰa- 'splendid'; /ʂuʂut(r)/ 'ornate headband' < *suʂuːtra- 'having fine thread', /ʂuʂʈa/ 'dry, dried' < *ɕuʂʈa- 'dried').

Kochetov (2007) reports a somewhat similar three-way coronal harmony which holds root-internally in the Finno-Ugric language **Komi-Permyak**, though in this case only sibilants are implicated. The relevant series are 'dental' /s, z/, retroflex /ʂ, ʐ, ʈʂ, ɖʐ/ and the (pre-)palatals /ɕ, ʑ, tɕ, dʑ/ (see Kochetov & Lobanova 2007). Here, too, the co-occurrence restriction makes crucial reference to same vs. different manner of articulation. In root-internal fricative…fricative (sibilant) pairs, retroflexes do not co-occur with non-retroflexes ('dentals' or palatals), whereas the latter may co-occur freely. Similarly, in pairs of the

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18 The pattern described here holds for word-initial (tautomorphemic) C_1VC_2 sequences, which are the subject of Arsenault & Kochetov's study. It is worth noting that co-occurring coronal of the same manner need not be *identical*; they are free to disagree in voicing and/or aspiration (e.g. /ʑ…ɕ/, /ʈʂʰ…ʈʂ/, /tʰ…d/).

affricate…affricate type retroflexes do not co-occur with non-retroflexes (i.e. palatals).[19] In different-manner sibilant pairs, on the other hand, the co-occurrence restriction seems to be a *dissimilatory* one: a sibilant fricative and affricate of the same class will not co-occur, but pairs which differ in both manner and (minor) place of articulation are well represented (e.g. /tɕ…ẓ/, /s…ʈʂ/). There is even some historical evidence for overt dissimilation in different-manner sequences (/tɕuẓ-nɨ/ < /ʈʂuẓ-nɨ/ 'to be born').

The sibilant harmony systems examined so far have typically involved alveolar vs. postalveolar and/or apical vs. laminal distinctions of some kind. It is far less common for sibilant harmony to involve a (genuine) *dental* vs. alveolar contrast. Nevertheless, a few such cases are found in the database, all of them belonging to the Northern subgroup of the Athapaskan family.[20] It may seem odd to discuss these under the rubric of sibilant harmony, given that (inter)dental fricatives and affricates are not usually classified as 'sibilants' (cf. Ladefoged & Maddieson 1996). Nevertheless, the cases in question clearly belong in this category. Two of these are three-way harmony systems which also involve unambiguous sibilant distinctions. Furthermore, all are historically cognate with the sibilant harmony systems that are observed in other Athapaskan languages (Navajo, Apache, etc.) that were discussed earlier in this section.

One of the Athapaskan languages in question is **Tahltan** (Hardwick 1984, Nater 1989, Shaw 1991, Halle 1995, Clements 2001, Levi 2004), where a three-way harmony holds between the dental /tθ, tθ', dð, θ, ð/, alveolar /ts, ts', dz, s, z/ and (lamino-)postalveolar /tʃ, tʃ', dʒ, ʃ, ʒ/ series. As in other Athapaskan sibilant harmony systems, the directionality is right-to-left in Tahltan, applying from root to prefix or from prefix to earlier prefix. The dental (/θ/) and alveolar (/s/) series of Tahltan are cognate with the alveolar (/s/) and postalveolar (/ʃ/) series, respectively, in languages such as Navajo and Apache. These two series are reflexes of the Proto-Athapaskan *s and *ʃ/*ʃʷ series, respectively (all relevant languages have merged the original *ʃ and *ʃʷ series). If anything, the data reported by Hardwick (1984) indicates that the third series in Tahltan (/ʃ/, etc., which go back to Proto-Athapaskan front velars) plays a more marginal role in the Tahltan coronal harmony system, and likely represents a later expansion of what was originally a two-way system; see §6.3.3 for discussion.

The Doig River dialect of **Dane-zaa** (**Beaver**), as described by Story (1989), also displays three-way sibilant harmony involving dental, alveolar and postalveolar series, though much less systematically so than in Tahltan. Here, too, the present-day dental and alveolar series go back to the Proto-Athapaskan *s and *ʃ/*ʃʷ series, respectively. Story (1989) de-

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[19] In affricate…affricate pairs, the two sibilants are always fully identical (/ʈʂ…ʈʂ/, /dʑ…dʑ/, etc.), but this need not be true for fricative…fricative pairs, which may differ in voicing (e.g. /s…z/, /ɕ…ʑ/). It is worth noting that the development of an obstruent voicing contrast is an innovation within the Permian branch of Finno-Ugric.

[20] A point that may be relevant in this context is the fact that (inter)dental affricates like /tθ, tθ', dð/ are extremely rare in the world's languages. Athapaskan is one of the few families where such segments are fairly widespread.

scribes the dental series as ‘postdental’, which may indicate that these are indeed true sibilants, i.e. [ts̪, ts̪’, dz̪, s̪, z̪] rather than [tθ, tθ’, dð, θ, ð].

Dakelh (**Carrier**), another Northern Athapaskan language, likewise has a contrast between dental and alveolar sibilants (/s̪/ vs. /s/, etc.), although the distinction is fast disappearing, or has already been lost, in most dialects (William Poser, pers. comm.; Story 1984).[21] Even though none of the Dakelh dialects are reported to have sibilant harmony, certain facts might hint at the existence of harmony alternations at some point in the past. The Proto-Athapaskan conjugation marker **se-*, which ought to have yielded dental /s̪-/ in Dakelh, has two distinct reflexes, /s̪-/ and /s-/, depending on its morpho-semantic function. As a perfective marker, **se-* has the expected reflex /s̪-/; as a negation marker, however, it instead shows up as /s-/. One conceivable explanation for this unexpected bifurcation in Dakelh might be that a once regular phonologically conditioned harmony alternation /s̪-/ → [s̪-] ~ [s-] was levelled in different directions depending on morphological context. In the perfective paradigm, the [s̪-] variant was generalized (and as a perfective marker the morpheme thus retained /s̪-/ as its underlying form), whereas in negative paradigms [s-] was generalized, resulting in the negation marker being reanalyzed as underlyingly /s-/.

A fourth Northern Athapaskan language (neighboring on Dakelh) is relevant in this context as well, even though its consonant harmony system strictly speaking does not qualify as a coronal harmony. This is **Tsilhqot’in** (**Chilcotin**), the sibilant *pharyngealization* harmony of which is described in §2.4.2 below. The phonological contrast on which the Tsilhqot’in harmony is based is synchronically a matter of pharyngealized vs. non-pharyngealized alveolar sibilants. Nevertheless, there is little doubt that this reflects an earlier dental vs. alveolar distinction (going back, ultimately, to the Proto-Athapaskan *s vs. *ʃ/*$ʃ^w$ contrast). See Hansson (2007c) for details on the historical origins and development of Tsilhqot’in sibilant pharyngealization harmony.

Before moving on to coronal harmony involving non-sibilants, a final example of sibilant harmony deserves mention which displays some unusual characteristics. Several of the Formosan languages (the Austronesian languages of Taiwan) have undergone certain historical sound changes—to some extent sporadic rather than regular—which all appear to be instances of sibilant harmony (Blust 1995). As conventionally reconstructed, Proto-Austronesian had three sibilants, **s*, **S* and **C*, which may have been /ʃ/, /s/ and /ts/, respectively. In Formosan languages, these often show unexpected reflexes, typically due to assimilation to another sibilant elsewhere in the word. Thus, in **Paiwan** (SE Taiwan), we find the following: **s…S* > **S…S* (**liseqeS* > **liSeqeS* > /liseqes/ ‘nit, egg of a louse’), **S…s* > **s…s* (**Sasaq* > **sasaq* > /tataq/ ‘to whet (on large stone)’), **C…S* > **S…S* (**CaSaw* > **SaSaw* > /sasaw/ ‘outdoors, outside’; cf. dialectal non-harmonized /tsasaw/), **C…s* > **C…C* (**Cangis* > **CangiC* > /tsangits/ ‘to weep, cry’). Note that the last two examples involve total assimilation between a

[21] The same is true for many nearby and closely related languages, such as Babine-Witsuwit’en (Story 1984, Hargus 2007), Sekani (Hargus 1988) and Kaska (Moore 2002).

fricative and an affricate, and may therefore belong instead in the category of stricture harmony (§2.4.6).

In **Saisiyat** (NW Taiwan), the following are some of the attested assimilations: **s…S* > **S…S* (**liseqeS* > **liSeqeS* > /Liʔʃiʃ/ 'nit, egg of a louse'), **S…z* > **s…z* (**Sajek* > **Sazek* > /sazek/ 'smell'), **C…S* > **S…S* (**CingaS* > **SingaS* > /ʃingaʃ/ 'food particles caught between teeth'), **C…s* > **s…s* (**Cangis* > **sangis* > /h-…-angih/ 'to cry, weep'; attested only with a -VC- infix). Again, assimilation appears at times to involve stricture (affricate vs. fricative) rather than minor-place distinctions like alveolar vs. postalveolar. However, this is less clear in Saisiyat than in Paiwan, since **C* has the regular reflex /s/; it is possible that **C*, though originally an affricate, did not undergo assimilation until after it had become a fricative.

The third language Blust (1995) discusses, **Thao** (Central Taiwan), has developed an exceptionally large inventory of fricatives, including at least /f, v, θ, ð, s, ʃ, ɬ, h/. Thao shows evidence of various assimilations that are similar to the ones described above for Paiwan and Saisiyat, e.g., **C…S* > **S…S* (**CaqiS* > /ʃaqiʃ/ 'sew'; as **C* regularly yields /θ/, the development was likely **C…S* > *θ…ʃ > ʃ…ʃ in this case), **s…S* > **S…S* (**dakeS* > **sakeS* > **SakeS* > /ʃakiʃ/ 'camphor laurel'), **S…s* > **s…s* (**Sidi* > **Sisi* > **sisi* > /sisi/ 'goat'). Interestingly, these sibilant assimilations affect the lateral fricative /ɬ/ as well; thus we find examples of **s…ɬ* > *ɬ…ɬ* (**daRa* > **saɬa* > /ɬaɬa/ 'Formosan maple'; **zaRum* > **saɬum* > /ɬaɬum/ 'needle'). In addition, Blust reports sporadic idiolectal assimilation in at least one /ʃ…ɬ/ word, /ʃ-m-auɬin/ 'to swing', pronounced by one speaker as [ʃ-m-auʃin] (progressive ʃ…ɬ → ʃ…ʃ) and by another as [ɬ-m-auɬin] (regressive ʃ…ɬ → ɬ…ɬ). Blust also notes that some speakers assimilate /ɬ…ð/ sequences to [ɬ…ɬ] in rapid or unpremeditated speech ([ɬiɬaʃan] for /ɬiðaʃan/ 'male of Swinhoe's blue pheasant', [faɬuɬ] for /faɬuð/ 'Formosan green pigeon').

The participation of /ɬ/ in the Thao harmony interactions is remarkable, given that lateral fricatives are not typically counted as sibilants. More importantly, lateral fricatives and affricates fail to participate in sibilant harmony in any of the Athapaskan languages, The neutrality of laterals in Athapaskan coronal harmonies has been taken as evidence bearing on the location of [±lateral] in feature-geometric models (Shaw 1991, Blevins 1994), based on the assumption that consonant harmony respects autosegmental locality, such that specifications on intervening segments will inevitably result in blocking (see §1.2.2 above). However, the present survey suggests that blocking *does not* as a rule occur in consonant harmony systems, regardless of the nature of the intervening material (see §3.2 for detailed discussion). The existence of long-distance assimilations between /ɬ/ and /s/ in Thao casts further doubt on the empirical validity of the argument that [±lateral] must reside at a feature-geometric node higher up than [±anterior] and [±distributed].

2.4.1.2. Non-Sibilant Coronal Harmony

Although the vast majority of coronal harmony systems revolve around sibilant contrasts, consonant harmony can also be defined over other types of coronals, such as stops, nasals and/or liquids. It should be stressed that the cases enumerated in this section form a heterogeneous class; the only thing they have in common is that non-sibilants take part in the harmony interaction. In some of the languages, the harmony exclusively affects non-sibilants, while in others we find stops interacting with sibilant affricates. In the latter case, it is often difficult to determine whether stricture harmony (§2.4.6) might be a more appropriate classification. Note also that those cases where harmony involves liquids exclusively (e.g. laterals interacting with rhotics) are here assigned to a separate category of liquid harmony (§2.4.5), though such phenomena might well be seen as a particular subtype of coronal harmony.

One example of non-sibilant coronal harmony has already been mentioned in §2.3 above: the root-internal harmony found among dentals and alveolars in many Western Nilotic languages (Heusing 2004). This was illustrated for **Päri** in (4)–(5); some relevant examples are repeated in (11) for ease of reference.

(11) Päri: root-internal coronal harmony (Andersen 1988)

a. Well-formed roots with multiple coronals

n̪ɔt̪	'sucking'
d̪á:n̪-ɛ̂`	'person (ergative)'
àtwá:t`	'adult male elephant'
àdú:nd-ɔ̂`	'heart'

b. Disallowed root-internal combinations

*d̪…n	*d̪…nd	*d̪…t	*t̪…n	*t̪…nd	(etc.)
*d…n̪	*d…n̪d̪	*d…t̪	*t…n̪	*t…n̪d̪	(etc.)

c. Root-final consonant alternations feed coronal harmony

Unpossessed	*Possessed (1Sg)*	
dè:l	dè:nd-á	'skin' vs. 'my skin'
t̪ùol	t̪úon̪d̪-à	'snake' vs. 'my snake'
tà-à	tà:n:-á	'pancreas' vs. 'my pancreas'
ùt̪ɔ́`-ó	ùt̪ó:n̪`-á	'fox' vs. 'my fox'

Päri has a dental vs. alveolar contrast in stops and nasals, and these are precisely the segments that interact in the consonant harmony. The same is also true of **Anywa** (Anuak; Reh 1996), which shows alternations of the same kind as in (5) and (11c) above.[22] The liquids /l, r/, by

[22] Although Anywa does have both dental and alveolar nasals, Reh (1996) states that dental [n̪] is only found in words which also contain a dental stop, which suggests that it is a mere surface variant (allophone) of /n/. However, dental [n̪] also occurs independently of harmony, arising through the kind of root-final morphophonological 'mutations' shown in (11c) for Päri, such as in Anywa [pò:n̪:ò] 'become smooth' (from /pɔ̀:d̪-/ 'be smooth', where the nasal retains the dentality of the underlying /d̪/). While it is true that the occurrence of [n̪] in surface forms is generally predictable, it is not strictly 'allophonic' in the traditional sense, since

contrast, are always alveolar; for the purposes of harmony, they are neutral, and co-occur freely with dentals and other alveolars alike. Root-internal coronal harmony seems to operate almost identically in **Shilluk** (Gilley 1992); here, too, both nasals and stops participate in the harmony (e.g., /t̪î̱n̪/ 'small' vs. /ti̱n/ 'today'; underlining indicates [+ATR], or 'expanded pharynx'). In Shilluk, just as in Päri, harmony is fed by various morphophonological alternations affecting root-final consonants (cf. the Päri forms in (11c)). However, in Shilluk, a derived root-final alveolar appears to *trigger* harmony rather than undergo it. For example, when the final /l/ of Shilluk /t̪al/ 'cook (trans.)' changes to [t] or [d] in certain morphological contexts, the root-initial /t̪/ assimilates to it rather than vice versa (antipassive [ta̱ːt], instrumental [tā̱ːd-ā]).

Päri, Anywa and Shilluk belong to the Northern division of the Lwoo branch of Western Nilotic. Various languages in the Southern Lwoo subbranch, by contrast, lack a dental vs. alveolar distinction in nasals (due to merger, as reconstructed by Heusing 2004), but maintain the root-internal coronal harmony restriction on oral stops. These include **Adhola** (Dhopadhola; Heusing 2004), **Alur** (Knappert 1963, Burssens 1969, Tucker 1969, Heusing 2004; see Mester 1988b) and **Luo** (Dholuo; Tucker 1994, Heusing 2004; see Yip 1989, Padgett 1995). In these languages, the alveolar nasal /n/ acts as a neutral segment, just like the alveolar liquids /l, r/ do in all of the Western Nilotic languages mentioned thus far. Tucker (1994) does not explicitly discuss the interaction of root-final morphophonological alternations (such as /l/ → [t]) with coronal harmony in Luo. However, singular-plural pairs such as [t̪uoːl] 'snake' vs. [t̪ʊ́ɔ́ːndɛ̂] (pl.) and [t̪ʊɔːn] 'male, brave man' vs. [t̪uoːndi] (pl.) suggest that such alternations *do not* feed coronal harmony in Luo but rather gives rise to surface exceptions to it. In this respect Luo patterns differently from Päri, Anywa and Shilluk.[23]

In addition to the Lwoo languages, Western Nilotic contains two other branches, Dinka-Nuer and Burun-Mabaan. According to Tucker (1994:31, n. 30), coronal harmony does not exist in the Dinka-Nuer languages, 'where dental/alveolar sequences occur'. However, it is

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dental [n̪] can in part occur in the same *phonological* environments as alveolar [n] does. This renders Anywa somewhat analogous to Nkore-Kiga sibilant harmony, which is dealt with at length in §5.1.2. In Nkore-Kiga, the distribution of [s] vs. [ʃ] is largely predictable, mostly based on the quality of the following vowel, but a surface contrast between […ʃa] and […sa] does exist, reflecting /S-a/ vs. /…S-i-a/ (the latter with causative /-i-/). The fact that coronal harmony in Anywa and Nkore-Kiga operates, at least in part, over phonological distinctions which are not underlyingly contrastive has implications for questions of how the selection of eligible trigger-target pairs—and the involvement of similarity relations in that selection—relates to contrastivity and inventory structure (see Rose & Walker 2004 and Mackenzie 2005 for discussion of Anywa on this point).

[23] Note that dental [n̪d̪] clusters do occur morpheme-internally in Luo (reflecting phonemic /nd̪/). What the examples above seem to show is that a root-final *derived* nasal-stop cluster remains consistently alveolar ([nd]), rather than become [n̪d̪] due to harmony with a root-initial dental.

unclear whether Tucker's statement is true of roots in general, or only of those root allomorphs which are derived through final-consonant alternations, as in [t̪ə̪t] (antipassive of the root /t̪a̪ːl/ 'cook', cited from Andersen 1999). The final-/t/ antipassive formation—widespread throughout Western Nilotic—arguably goes back to what originally was a separate antipassive suffix **-t* (Hall & Hall 1996). Therefore, such examples might simply indicate that Dinka-Nuer languages have not extended harmony to derived contexts (cf. the discussion of derived [nd] in Luo above).

In the third branch of Western Nilotic, the sparsely documented Burun-Mabaan languages, coronal harmony is found. What is more, it may give rise to harmony alternations beyond the confines of the root. This is seen in **Mayak**, one of the Northern Burun varieties (Andersen 1999). In the Mayak consonant inventory, a dental vs. alveolar contrast exists among stops. The dental nasal [n̪] does occur, but only as an allophone of /n/ in the clusters [n̪d̪], [n̪t̪]. According to Andersen's (1999) analysis, the phonemic dental vs. alveolar contrast is between /t̪, d̪/ and /t, d/. However, /d̪/ is in certain predictable contexts realized as fricative [ð], and /d/ as implosive [ɗ], such that the surface contrast is [t̪, d̪, ð] vs. [t, d, ɗ]. Andersen (1999) does not discuss whether dentals and alveolars co-occur root-internally in Mayak, but the only potential example of such a disharmonic root is found in the data he cites is the form [pɪɗat̪] 'shell'. This is likely to be bimorphemic /pɪd-at̪/, however; as in other Western Nilotic languages, Mayak roots generally have the shape CV(V)C, and Andersen cites many nouns ending in […at̪].

Beyond the root, coronal harmony optionally extends to various suffixes of the shape /-Vt̪/, especially in nouns. When a suffix such as singulative /-ɛt̪/, /-ʌt̪/ or /-it̪/ is attached to a root containing alveolar /t/ or /d/ (the latter realized as either [d] or [ɗ]), the suffixal /t̪/ optionally becomes alveolar, as illustrated in (12a). The triggering alveolar may be either root-final or root-initial. Note that only the *contrastively* alveolar consonants trigger harmony, not the redundantly alveolar sonorants /n, l, r/ (12b).

(12) Mayak: coronal harmony (optional) in /-Vt̪/ suffixes (Andersen 1999)

a. Harmony triggered by [t, d, ɗ] in root

leɣ-it̪	'tooth'
ɡim-it̪	'cheek'
wʌð-it̪	'buttock'
tiɗ-ʌt̪ ~ tiɗ-ʌt	'doctor'
tuɣ-it̪ ~ tuɣ-it	'back of head'

b. Alveolar [l, r, n] do not trigger harmony

bɛːl-ɛt̪	'cane'
riŋ-it̪	'meat'
ʔin-ʌt̪	'intestine'
kan-ɪt̪	'torch'

c. Harmony applied across intervening alveolar [n]
ɗɪːn-ɛt̪ ~ ɗɪːn-ɛt 'bird'
kɛt-ɪn-ɛt̪ ~ kɛt-ɪn-ɛt 'star'

Note that not only does alveolar [n] not trigger harmony, it also does not block it, and is thus both neutral (12b) and transparent (12c). The same is presumably also true of [l, r], though Andersen (1999) cites no forms that bear on their transparency.

Before leaving Western Nilotic coronal harmony, it is worth emphasizing a point made in previous analyses (Yip 1989, Padgett 1995), namely that in most of these languages, dental and alveolar stops (and nasals, where applicable) freely co-occur with certain other obstruents which are also coronal, such as /s/ (in Luo) and the 'palatals' /c, ɟ/. In virtually all of the languages, the 'palatals' are either optionally or consistently realized as postalveolar affricates, [tʃ, dʒ], judging by descriptive sources; Andersen (1999) even gives [ʃ] as a possible realization of /c/ in Mayak. As for Luo /s/, Yip (1989) and Padgett (1995) analyze it as [–anterior] and therefore exempt from the harmony (which they assume holds only for coronal pairs agreeing in [±anterior]). Nevertheless, Tucker (1994) quite explicitly classifies Luo /s/ as alveolar, along with /t, d, n, l, r/, and does not mention any alternative realizations of this segment that might suggest that it belongs with the 'palatals'. It seems more appropriate to conclude that the neutrality of /s/ in Luo is a consequence either of Western Nilotic coronal harmony being confined to those segments that are *contrastively* dental or alveolar (though Anywa is problematic in this regard; see n. 22 above). Alternatively, the harmony interactions might be limited to pairs of coronals which have identical constriction degree (i.e. agree in [±continuant]), but the alternate realization of Mayak /d̪/ as [ð] is hard to reconcile with this view.

In Western Nilotic, coronal harmony is based on the dental vs. alveolar distinction (or [±distributed]). Another opposition over which harmony may be defined is retroflex vs. non-retroflex.[24] For example, dental /t̪/ and retroflex /ʈ/ (the latter phonetically affricated and velarized [ʈʂˠ]) are not allowed to co-occur within roots in the Austronesian language **Pohnpeian** (Ponapean; Rehg & Sohl 1981), though this may be viewed as a case of secondary-articulation harmony (§2.4.3; see Hansson 2007c). In another Austronesian language, **Javanese**, dental and retroflex stops are likewise not allowed to co-occur in roots, especially in root-initial C_1VC_2 sequences (Uhlenbeck 1949, Mester 1988b; see also Yip 1989). However, in Javanese this is merely part of a more general restriction against the co-occurrence of non-identical consonants with identical place and/or manner of articulation. Thus, none of the labials /p, b, m, w/ co-occur with each other, nor do any of the 'palatals' /c, ɟ, s, ɲ/, the coronal

[24] Recall from §2.4.1.1 that retroflex vs. non-retroflex contrasts may form the basis of sibilant harmony as well (Rwanda, Rumsen, Benchnon, Capanahua, Ixil, Kalasha, Komi-Permyak). With the exception of Kalasha (Arsenault & Kochetov 2008, 2009; see below), these languages have no retroflexion contrast in non-sibilant coronals (stops, nasals), and the latter are neutral and do not act as harmony triggers, targets or blockers.

stops /t̪, d̪, ʈ, ɖ/, the liquids /l̪, r/, and so forth.[25] What is important in this context is that retroflex…dental stop sequences (in either order) are above the similarity threshold at which this co-occurrence restriction holds.

More clear-cut examples of coronal harmony where retroflex and non-retroflex segments interact are found in aboriginal languages of Northern Australia, such as **Gooniyandi** (McGregor 1990, Steriade 1995a, 1995b, Gafos 1999), **Murrinh-patha** (Murinbata; Street & Mollinjin 1981, Steriade 1995a) and **Gaagudju** (Hamilton 1993, cited by Gafos 1999); see also Evans (1995, 2003) on **Mayali**. The discussion here is based mainly on the description in Gafos (1999). Languages of this area typically have a four-way contrast among coronal stops, nasals and laterals: lamino-dental /t̪, d̪, n̪, l̪/, apico-alveolar /t, d, n, l/, apico-postalveolar (= retroflex) /ʈ, ɖ, ɳ, ɭ/, and lamino-postalveolar (= 'palato-alveolar') /t̠, d̠, n̠, l̠/ (see Ladfoged & Maddieson 1996). In addition, there is usually an apico-alveolar vs. apico-postalveolar contrast in rhotics, between /r/ (a tap or trill) and either /ɻ/ (an approximant) or /ɽ/ (a flap).

In a great number of these Australian languages, the apico-alveolar vs. apico-postalveolar contrast is maintained only postvocalically, and is thus neutralized in word-initial position. This is not surprising, given that the perceptual cues for retroflexion are primarily located in VC rather than CV transitions (Steriade 1995a, 1999). In Gooniyandi, this word-initial neutralization results in free variation between alveolar and retroflex articulations, as shown in (13a). In Gaagudju, on the other hand, word-initial apicals are consistently realized as alveolar (e.g. [naːwu] 'he'). In both languages, however, the generalizations about word-initial apical realization are overridden by coronal harmony. When followed by another apical, an initial apical consistently agrees with it; this is shown for Gooniyandi in (13b). Finally, coronal harmony only governs the realization of apicals in positions of neutralization (i.e. word-initially); as the examples in (13c) illustrate, harmony never tampers with the contrastive specifications of apicals in postvocalic environments.

(13) Gooniyandi: harmony among apicals (McGregor 1990 *apud* Steriade 1995a)

a. Word-initial neutralization (free variation, alveolar ~ retroflex)

tuːwu ~ ʈuːwu	'cave'	
nɑːgʌ ~ ɳɑːgʌ	'dress'	

b. Word-initial apical harmonizes with following apical

tili	'light'	(not *[ʈili])
ʈɨɽɨppɪndi	'he entered'	(~ [tɨɽɨppɪndi] only rarely)

c. No harmony (nor free variation) in non-initial positions

kiliɳi	'grass'	(not *[kiɭiɳi])
waɖguluna	'I bring them'	(not *[wadguluna])

[25] The so-called 'palatal' obstruents of Javanese are in fact alveolar, though they behave phonologically as palatals to some extent; thus /c, ɟ/ = [ts, dz] (see Ladefoged & Maddieson 1996 and references cited there).

A very similar phenomenon is found in certain languages of the Dravidian family, where phonological retroflex vs. non-retroflex stop contrasts are quite common. One such case is the Northern Dravidian language **Malto** (Mahapatra 1979), in which dental /t, d/ contrast with retroflex /ʈ, ɖ/. In Malto, dental and retroflex stops cannot co-occur as C_1 and C_2 in tautomorphemic $C_1V(C)C_2$ sequences. In all the forms that Mahapatra (1979) cites in support of this generalization, C_1 is root-initial (e.g. /ʈuːɖ/ 'tiger', /ɖanɖa/ 'staff', /dudu/ 'mother', /toːtotri/ 'quickly'). This is significant, because retroflex stops did not occur in root-initial position in Proto-Dravidian. Malto roots like /ɖanɖa/ 'staff' are the direct result of a sound change of anticipatory retroflexion harmony (Subrahmanyam 1983), as witnessed by cognates such as Kannada /daɖi, daɳɖi/ 'staff, cudgel', Tamil /taʈi/ 'stick' (Burrow & Emeneau 1984). Coronal harmony in Malto is thus virtually identical to that found in the Northern Australian languages, especially that of Gaagudju, where initial apicals are consistently non-retroflex except in harmony contexts. Finally, note that just as in the Western Nilotic cases discussed earlier the only consonants participating in Malto coronal harmony are those which are *contrastively* dental or retroflex, namely the oral stops. For example, the retroflex flap /ɽ/ does not trigger coronal harmony (/taɽe/ 'grinding stone'), and consonants like /s, n, l/ do not undergo it. Furthermore, the 'palatals' /c, ɟ/ do not interact with the harmony in any way either. It is not quite clear whether these are true (dorso-)palatals or coronals; Mahapatra describes both as 'alveo-palatal affricates', transcribing /c/ phonetically as [c͡ç] and /ɟ/ as [ɟ͡ʑ].

The Indo-Aryan language **Kalasha** (Arsenault & Kochetov 2008, 2009) displays the exact same kind of root-internal co-occurrence restriction on dental and retroflex stops. /t, t^h, d, d^h/ vs. /ʈ, $ʈ^h$, ɖ, $ɖ^h$/ (at least judging by coronal-coronal co-occurrence patterns in root-initial C_1VC_2 sequences). As in Malto, co-occurring coronal stops are not required to be identical, merely to agree in retroflexion (cf. /t^hedi/ 'now', /$ʈ^h$eʈ karik/ 'to scatter'). As discussed in §2.4.1.1, Kalasha retroflexion harmony encompasses sibilant fricatives and affricates as well, in that all pairs of co-occurring coronal obstruents which have identical manner of articulation (affricate…affricate, fricative…fricative, stop…stop) must agree in retroflexion. Kalasha is therefore a rather unique case in that one and the same coronal harmony restriction holds for sibilant…sibilant and nonsibilant…nonsibilant pairs within the same language.

Another Indo-Aryan case of long-distance assimilation in retroflexion, which is often cited in generative analyses of consonant harmony, is the *n*-retroflexion process, or *ṇati*, that occurred in **Vedic Sanskrit** (Wackernagel 1896, Whitney 1889, MacDonell 1910, Allen 1951, Schein & Steriade 1986, Ní Chiosáin & Padgett 1997, Gafos 1999). This case is described in great detail in a later section (§3.2.3), to which the reader is referred. It is argued there that Vedic Sanskrit *n*-retroflexion is *not* a case of consonant harmony, and that it displays a range of characteristics which are radically different from those seen in the other, unequivocal long-distance consonant assimilations that are surveyed here.

The last major class of coronal harmony phenomena to be covered in this section consists of cases in which alveolar (or dental) stops interact with postalveolar affricates like [tʃ], the latter often described with terms like 'palato-alveolar', 'alveo-palatal' or just 'palatal'. Because assimilation of this kind involves a manner distinction as well (stop vs. affricate), some or all of the examples might be argued to belong in the category of stricture harmony (§2.4.6). They are classified here as coronal harmony for two reasons. Firstly, the 'minor-place' contrast involved ([t] vs. [tʃ], [d] vs. [dʒ]) is essentially identical to the alveolar vs. postalveolar opposition which so often forms the basis of *sibilant* coronal harmony systems ([s] vs. [ʃ], [ts] vs. [tʃ], etc.). Secondly, the [t]-[tʃ] harmonies examined here and sibilant harmonies of the [(t)s]-[(t)ʃ] type both exhibit significant parallels with the kinds of alveolar-postalveolar interactions that are observed in phonological speech errors, as will be detailed in chapter 6.

In the dialect of Aymara described in de Lucca (1987), which is tentatively labelled **'Bolivian' Aymara** by MacEachern (1999), the root-internal co-occurrence of alveolar /t, t^h, t'/ and 'alveo-palatal' /tʃ, tʃ^h, tʃ'/ is quite limited.[26] As noted by MacEachern, roots with /t^h…tʃ^h/, /tʃ^h…t^h/, /t'…tʃ^h/ or /tʃ'…t^h/ are unattested. Certain other conceivable combinations are independently ruled out by various laryngeal co-occurrence restrictions, such as /t^h…tʃ'/, /tʃ^h…t'/, /t'…tʃ'/, /tʃ'…t'/ (see MacEachern 1999 for details.) These lexical gaps would suggest that, at least as regards laryngeally specified coronal plosives (ejectives and aspirates) alveolars and postalveolars are not allowed to co-occur root-internally in Bolivian Aymara. MacEachern does not mention the behavior of the plain unaspirated plosives /t, tʃ/ in this respect, but a manual search in de Lucca (1987) for word-initial /TVČ/ or /ČVT/ sequences (where T ∈ {t, t^h, t'} and Č ∈ {tʃ, tʃ^h, tʃ'}) shows some interesting results. Although /ČVt/ sequences are quite common (14a), not a single example of /TVtʃ/ was found.[27] It appears that when laryngeally *un*specified plosives are involved, the restriction is directional, banning alveolar…postalveolar sequences (14b) while at the same time permitting postalveolar…alveolar ones (14a).

(14) Bolivian Aymara: root-internal coronal harmony (data from de Lucca 1987)

a. Well-formed roots combining alveolars and postalveolars

tʃatu	'jug, small vessel of clay'
tʃitu	'minute, tiny (dial.)'
tʃ^{h}ita	'string, row of objects put on a thread'
tʃ'uta	'collision of two round objects'

b. Disallowed root-internal sequences

*/t…tʃ/
*/t^h…tʃ/
*/t'…tʃ/
(also */t^h…tʃ^h/, */tʃ^h…t^h/, */t'…tʃ^h/, */tʃ'…t^h/, etc.; see text)

[26] Bolivian Aymara also has alveolar /s/, which appears to freely co-occur with the postalveolar affricates /tʃ, tʃ^h, tʃ'/.

[27] Due to a 'leftness effect', an aspirated or ejective stop always occurs earlier in the morpheme than a voiceless unaspirated stop, hence */t…tʃ'/, */t…tʃ^h/, etc. are independently ruled out (MacEachern 1999).

In the West Chadic language **Kera** (Ebert 1979), a similarly directional assimilation between /t/ and /tʃ/ is found. In this language, an original /t/ is sometimes realized as [tʃ], either optionally or obligatorily (Ebert 1979:7). Furthermore, the feminine prefix, which is normally [t-] in presonorant contexts, is systematically realized as [tʃ-] if another [tʃ] follows in the stem (Ebert 1979:146–147), as illustrated in (15).

(15) Kera: coronal harmony effects (data from Ebert 1979)

a. Root-internal assimilation of /t/ to following /tʃ/ (sporadic?)

tutʃí ~ tʃutʃí	'tamarind'	
tʃətʃerkə́	'backbone'	(cf. Tupuri /tìtʃèrè/)

b. Alternations in feminine prefix /t-/

t-óːjá	'dog (fem.)'	(cf. masc. [k-óːja]/)
t-eːŋa	'dry (fem.)'	(cf. masc. [k-eːŋe])
tʃ-əːtʃə́	'small (fem.)'	(cf. masc. [k-oːtʃé])

In Kera, just as in Bolivian Aymara, sequences with the order alveolar…postalveolar are ruled out: *[t…tʃ] is banned, whereas [tʃ…t] is allowed (/tʃérté/ 'split'). While the harmony effect in Aymara is manifested solely as a static distributional pattern, its Kera counterpart shows evidence, synchronic as well as diachronic, of an active assimilation process /t…tʃ/ → [tʃ…tʃ].

A similar pattern involving 'palatals' is attested in certain South-Central Dravidian languages, including **Pengo** (Burrow & Bhattacharya 1970). In Pengo, a root-initial dental stop /t, d/ assimilates—to some extent optionally—to a root-final 'palatal' (rendered as 'c, j' in Burrow & Bhattacharya 1970). Although the description is not explicit about the phonetic realization of 'c' and 'j', I will assume for the present purposes that these are (lamino)-postalveolar affricates, and will represent them as /tʃ, dʒ/.[28] As the forms in (16a) show, there is both comparative-historical and synchronic evidence for harmony in Pengo: morphologically driven alternations in root-final consonants may feed harmony, triggering a change in the root-initial consonant as well, as in the first example in (16a). The Pengo facts are in this respect quite similar to those of the root-internal coronal harmony in Western Nilotic languages (Päri, Shilluk, etc.) described earlier in this section.

[28] It is possible that /tɕ, dʑ/ or /cç, ɟʝ/ would be more accurate renderings (cf. the discussion of Malto earlier in this section, and that of Kalasha sibilants in §2.4.1.1).

(16) Pengo: root-internal coronal harmony (data from Burrow & Bhattacharya 1970)

a. Dental harmonizes (optionally) to following postalveolar

titʃ- ~ tʃitʃ-	'to eat (past stem)'	(from /tin-/ 'eat')
toːtʃ- ~ tʃoːtʃ-	'to show'	
taːndʒ- ~ tʃaːndʒ-	'to weave (a garland)'	
dʒoːtʃ-	'to carry on the head'	(cf. Gondi /toːtʃaːnaː/)
tʃoːndʒ-	'to appear'	(cf. Kuvi /toːndʒ-/)

b. Root-internal postalveolar…dental sequences are allowed

tʃeta man-	'to be awake'
tʃinta ki-	'to think; to worry, be anxious'
dʒaːti	'caste'
dʒunda	'spinning top'

No harmony takes place in retroflex…'palatal' sequences (/ɖandʒ-/ 'to stick to'). The harmony in (16) is virtually without exception. If it is valid to equate the Pengo 'palatals' with postalveolar affricates, as has been done here, then Pengo displays the very same directionality effect as Bolivian Aymara and Kera: coronal harmony prohibits *[t…tʃ], while leaving [tʃ…t] unaffected.

Exactly the same process of assimilating coronal stop…affricate sequences like /t…tʃ/ and /d…dʒ/ to [tʃ…tʃ] and [dʒ…dʒ], respectively, seems to occur in the Eastern Berber language **Siwi**, spoken in Egypt. Under the rubric 'phonetical changes', Vycichl (2005:284) describes this process as one of the characteristics of the Siwi language. He cites three examples, two of which appear to be loanwords from Arabic ([lebdʒindʒa] 'eggplant' < Arab. /bidindʒaːn/, [edʒːriːdʒ] 'stairs' < Arab. /daradʒa/). The third is a morphologically complex form, the habitual /t-etʃː/ from /etʃː/ 'to eat', which is variably realized as [tetʃː] or as [tʃetʃː] ~ [tʃitʃː]. In all three examples cited, the trigger and target agree in voicing (as a result, they become completely identical), and this restriction is implicit in the wording of Vycichl's description of the change as well.

Finally, a similar kind of coronal harmony might be seen as playing a part in the complex patterns of featural affixation found in several Ethio-Semitic languages (McCarthy 1983, Akinlabi 1996, Rose 1997, 2004, Zoll 1998, Banksira 2000). In particular, some involvement of harmony might be inferred from the 'morphological palatalization' patterns of **Harari** (Leslau 1958, Rose 1997, 2004), especially as regards certain cases where palatalization targets multiple coronals at once. The description below is based on Rose (2004), to which the reader is referred for detailed discussion and formal (optimality-theoretic) analysis. In Harari, the 2SgF subject suffix /-i/ triggers 'palatalization' of a stem-final coronal (17a): alveolar obstruents become postalveolar sibilants (/t, t', d, s, z/ → [tʃ, tʃ', dʒ, ʃ, ʒ]), while alveolar sonorants become true (dorso-)palatals (/n/ → [ɲ], /l/ → [j]; /r/ is unaffected). If the stem-final consonant is not coronal, palatalization may instead target a coronal in stem-medial position (17b) or even stem-initial position (17c); in essence, palatalization targets the rightmost (non-/r/) coronal in the stem.[29]

(17) Harari: palatalization with 2SgFem /-i/ (data from Rose 2004)

	2SgMasc	*2SgFem*	
a.	kifat	kifatʃ-i	'open!'
	zimad	zimadʒ-i	'drag!'
	libas	libaʃ-i	'dress!'
	kifal	kifaj	'pay!'
b.	kitab	kitʃab-i	'write!'
	sidab	sidʒab-i	'insult!' (see also (19a))
	ħinak'	ħiɲak'-i	'strangle!'
c.	t'irag	tʃ'irag-i	'sweep!'
	sixar	ʃixar-i	'be drunk!'

When the stem contains more than one coronal, multiple palatalization may occur (18). If the stem-final consonant is a coronal sonorant (i.e. /l/ or /n/, as /r/ is not an eligible target), palatalization will typically also target a stem-medial coronal obstruent (18a), though some speakers also acknowledge single-palatalization variants (shown here in parentheses). In cases where a stem-initial coronal obstruent is followed by a stem-medial or stem-final coronal sonorant (18b), there appears to be more variability in whether the obstruent gets palatalized; female speakers seem to prefer the double-palatalization variants. If the order is sonorant…obstruent, only the obstruent gets palatalized (18c).

(18) Harari: double palatalization in multiple-coronal stems (obstruents and sonorants)

	2SgMasc	*2SgFem*	
a.	fit'an	fitʃ'aɲ-i (~ fit'aɲ-i)	'hurry!'
	gidal	gidʒaj (~ gidaj)	'kill!'
b.	dinak'	dʒiɲak'-i ~ diɲak'-i	'be surprised!'
	sik'al	ʃik'aj ~ sik'aj	'hang (tr.)!'
c.	dinabt'i	dinabtʃ'-i	'be frightened!' (see also (19b))

Of greatest relevance in the present context are cases where the stem contains more than one coronal *obstruent*. Here, too, double palatalization is optional (and, again, preferred by female speakers), as in the examples in (19) below (cf. also negative imperatives like 2SgMasc

[29] The domain for morphological palatalization in Harari appears to encompass not only the root but (certain) prefixes as well, such as 2Sg imperfective /t(i)-/, causative /at-/, and the relativizer /z-/ (see Rose 2004 for details).

[a-t-kitab] vs. 2SgFem [a-tʃ-kitʃab-i] ~ [a-t-kitʃab-i]; see n. 29 on the palatalization of prefix consonants). When a coronal sonorant intervenes between two obstruents being palatalized, as in (19b), it too gets targeted by palatalization, even though it is unaffected when only the second obstruent is palatalized.

(19) Harari: double palatalization in multiple-coronal stems (obstruent…obstruent)

	2SgMasc	*2SgFem*	
a.	bit'as	bitʃ'aʃ-i ~ bit'aʃ-i	'rip!'
	t'imad	tʃ'imadʒ-i ~ t'imadʒ-i	'tie, be strongly against!'
	sidab	ʃidʒab-i ~ sidʒab-i	'insult!'
b.	dinabt'i	dʒiɲabtʃ'-i ~ dinabtʃ'-i	'be frightened!'

It is conceivable to interpret the double-palatalization effect seen in (19) as being partly due to a coronal harmony effect, whereby alveolar…postalveolar sequences like [t…tʃ], [d…tʃ'], [t'…ʃ], [s…dʒ], etc., are (optionally) avoided in favor of postalveolar…postalveolar [tʃ…tʃ], [dʒ…tʃ'], and so forth. If such an interpretation is tenable, Harari would resemble Pengo, Kera, and Aymara both in terms of the directional asymmetry and with respect to the interaction of stops with affricates. (There are some obvious differences as well, such as the fact that stops and fricatives can interact in Harari.) Note also the obvious similarities between Harari and the cases of 'morphological palatalization' in certain Chadic languages (Gude, Miya) discussed in §2.4.1.1 above. The main differences are that in Harari, the 'coronal harmony' encompasses coronal stops /t (t') d/ along with sibilant fricatives /s z/ (though the 'palatalized' set is the same: /tʃ (tʃ') dʒ ʃ ʒ/), and the fact that double palatalization (i.e. 'harmony') is optional in Harari.

Rose (2004) considers a consonant harmony analysis of the Harari double-palatalization facts, but raises several arguments against it, concluding that 'while Harari palatalization bears some similarity to consonant harmony in that more than one coronal consonant is palatalized within a stem, it differs from other cases in enough ways to warrant an alternate analysis' (Rose 2004: 74). One argument against a consonant harmony analysis is the fact that an intervening sonorant gets palatalized as well, as in (19b) (cf. [ti-dʒɲabtʃ'-i] ~ [ti-dnabtʃ'-i] 'you are frightened')—though see §3.2.2.2 for discussion of how a demand for long-distance agreement (i.e. consonant harmony) may occasionally be met by means of (local) spreading through intervening segments (Hansson 2007b). Another problem with a harmony analysis of the Harari patterns is the fact that alveolar…postalveolar sequences are not prohibited or altered in the language in general, only in morphological-palatalization contexts (i.e. in forms with the 2SgFem /-i/ suffix). This argument is not necessarily conclusive; the specific avoidance of marked structures in derived (non-underlying) environments is a well-known phenomenon (Łubowicz 2002, McCarthy 2003a, Hall 2006). While an analysis of Harari in terms of consonant harmony is certainly not straightforward, it might be more feasible than Rose (2004) suggests.

A final and highly unusual case which cannot qualify as anything but (non-sibilant) coronal harmony is the 'click harmony' described for **Ndebele** by Sibanda (2004). Ndebele distinguishes clicks at three (anterior) places of articulation: dental /kǀ, kǀʰ, ɡǀ, ŋǀ/, postalveolar /k!, k!ʰ, ɡ!, ŋ!/ and alveolar lateral /kǁ, kǁʰ, ɡǁ, ŋǁ/.[30] While the Ndebele lexicon contains numerous roots with multiple clicks of the same (anterior) place, such as /-kǀʰiŋǀ-a/ 'drip', /-k!ok!-a/ 'collect, gather, organize' or /-kǁʰaŋǁatʰ-a/ 'gnaw', roots combining a dental with a postalveolar click, or a lateral click with either of the former, are completely absent. In other words, clicks that co-occur within a morpheme must agree in their (anterior) place of articulation, and this in all cases involves a coronal closure of some kind.

2.4.2. Dorsal and Labial Consonant Harmony

In the preceding section we saw how consonant harmony is very often defined over various 'minor place of articulation' distinctions which are specific to coronal consonants and are, in most feature-geometric models, encoded in terms of features dependent on the [coronal] articulator node. But what about the other major articulators, [dorsal] and [labial]? It is true that as a highly versatile articulator, the tongue tip/blade allows for a particularly rich inventory of potential subsidiary contrasts, but there are dorsal- and labial-specific distinctions which could be seen as parallel to these: labiodental vs. bilabial in the case of [labial] consonants, and velar vs. uvular (perhaps also velar vs. palatal) for [dorsal] consonants. It is logical to ask whether consonant harmony is ever defined over such *non*-coronal 'minor-place' distinctions. By analogy with the term 'coronal harmony', we can refer to these as 'dorsal harmony' and 'labial harmony'. Unfortunately, the latter term is already in frequent use as a synonym of 'rounding harmony', referring to a type of *vowel* harmony. To avoid confusion, I will instead refer to these as dorsal and labial *consonant* harmony, respectively.

Of the two, dorsal consonant harmony is most certainly attested, though it appears to be relatively rare. The clearest examples are found among the Totonacan languages, where dorsal consonant harmony is attested in both branches of the family, Totonac and Tepehua. For example, MacKay (1999) describes a process of 'uvular assimilation' in **Misantla Totonac**, whereby heteromorphemic /k…q/ sequences are harmonized to [q…q].[31] Although MacKay does not mention whether the *tauto*morphemic co-occurrence of /k/ and /q/ is prohibited as well, a tentative search for morpheme-internal /k…q/ and /q…k/ sequences throughout her grammar yielded no results. It may safely be assumed that dorsal consonant harmony in Misantla Totonac most likely holds (non-directionally) as a root-level co-occurrence restriction as well. In all of the heteromorphemic cases MacKay cites, where harmony results in [k] ~ [q]

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[30] Sibanda (2004:4) notes that all clicks in Ndebele have an affricated release (presumably of their posterior, dorsal closure); this is not indicated in the transcriptions given here.

[31] Due to an independent (and optional) process of postvocalic spirantization of /q/, such a harmonized /k…q/ sequence may be realized as [q…q], [q…χ], [χ…q] or [χ…χ], depending on the context.

alternations (or [k] ~ [χ]; see n. 31), the target velar is located in a derivational prefix and the trigger in the following root, as illustrated in (20a–b). As MacKay (1999) points out, the domain in which dorsal consonant harmony applies is morphologically defined: it consists of the *stem*, comprising the root and derivational prefixes (e.g. body-part or valence-changing prefixes). Inflectional prefixes lie outside the scope of the harmony, as examples like (20c) show. (Note especially the first form in (20c), where the second /k/ is assimilated but the first is not.) Finally, forms such as (20d) demonstrate that in heteromorphemic contexts, harmony operates in a strictly right-to-left fashion: /q…k/ sequences are not repaired.

(20) Misantla Totonac: dorsal consonant harmony (data from MacKay 1999)

a. Harmony alternation in body-part prefixes /-ka̰ːk-/, /maka-/:

míɴqá̰ːqpaχɛ̰́ʔ	/min-ka̰ːk-paqa̰ʔ/	‘your shoulder’
míŋká̰ːktʃa̰ːn	/min-ka̰ːk-tʃa̰ː-nḭ/	‘your shoulder’ [sic!]
ʔṵ́t maqáʃqɛ́t	/ut maka-ʃqat/	‘s/he scratches (with hand)’
ʔṵ́t makapáʃ	/ut maka-paʃ/	‘s/he bathes his/her hand’

b. Harmony alternation in other derivational prefixes (/maka-/, /lak-/):

maqaɬɔ́qwaɬ	/maka-ɬuqwan-la(ɬ)/	‘s/he tired [him/her]’
láχtʃáɴχʃ	/lak-tʃanqʃ/	‘s/he chops (bones)’

c. No harmony in inflectional prefixes (1Subj /ik-/, 1Obj /kin-/):

ʔḭ́kláqtsa̰qa̰	/ik-lak-tsa̰qa̰/	‘I chew [it]’
kḭ́sqɔjúniɬ	/kin-squ-jan-ni-la(ɬ)/	‘s/he smokes [it] for me’

d. No left-to-right harmony (/q…k/ sequences not subject to harmony):

sqɔkɔ́hɔɬ	/squ-kuhu-la(ɬ)/	‘it was smoked’

While there are morphological limitations on dorsal consonant harmony in Misantla Totonac, it is clear from MacKay’s description that the harmony interaction is not phonologically bounded. There are no particular types of segments (consonants or vowels) that act as opaque, blocking the propagation of harmony if they intervene between a uvular trigger and a preceding velar target. Nevertheless, the possibility must be entertained that the assimilating feature is transmitted from trigger to target by (strictly) local spreading, such that any and all intervening segments are phonetically affected as well. At first glance, this seems plausible in light of the fact that uvular [q, χ] (as well as [h]) do trigger lowering of an adjacent high vowel, as shown in (21a). However, this lowering effect is quite restricted in its scope. A vowel is only affected if it is *immediately* adjacent to a uvular; if another consonant intervenes, no lowering takes place (21b).[32] Secondly, when the vowel is a long /iː/, lowering frequently affects only that half of the vowel which is adjacent to the uvular, resulting in diphthongization (21c).

[32] In the closely related Papantla Totonac, it appears that an intervening consonant will not necessarily block the vowel lowering effect that uvulars trigger. Elorrieta (1996) (based on Levy Podolsky 1987 and cited by Bessell 1998) states that in Papantla Totonac, the vowel

(21) Misantla Totonac: vowel lowering by uvulars (data from MacKay 1999)

a. Lowering of /i, u/ adjacent to /q/ ([q, χ]):

ʃáːqɛɬ	/ʃaːqiɬ/	‘buzzard’
tʃutɔ́χʃ	/tʃutuqʃ/	‘lame’
stɔ̰χɔ̰nṵ́ʔ	/stṵqṵ-nV̰ʔ/	‘old woman’

b. No lowering across another consonant:

kíɬqɔ́ːɴɢnán	/kiɬ-ɬquːnq-nan/	‘s/he snores’	(*[kɛ́ɬqɔ́ːɴɢnán])
míláqtʃíʃit	/min-laq-tʃiʃit/	‘your eyelashes’	(*[míláqtʃɛ́ʃit])
páqʃúːtah	/paq-ʃuːtaɬ/	‘left-handed’	(*[páqʃɔ́ːtah])
ʔḭ́ʃmáːʔɔ̰́χʃuːt	/iʃ-maː-ṵqʃuː-Vt/	‘her/his name’	(*[ʔḭ́ʃmáːʔɔ̰́χʃɔːt])

c. Partial lowering of long /iː/ (to [ɛi̯] after /q/, [iə] before /q/):

míɴqɛ́i̯ɲ̰ʃílḭt	/min-qiːn-ʃiḭ-Vt/	‘your mucus’
hɔ́n máːχɛ́i̯táːná̰ʔ	/hun maː-qiːtaː-nV̰ʔ/	‘DET bossy one’
ʔḭ́klíəqá̰wa̰ɬ	/ik-liː-qa̰wa̰-la(ɬ)/	‘I spoke for/of X’

As is evident from (20) above, no comparable limitations hold for the /k…q/ → [q…q] assimilations. Even though it is conceivable that the local lowering and retraction effects of /q/ on neighboring segments were somehow implicated in the historical emergence of the consonant harmony patterns, these effects are not directly involved in the synchronic harmony interactions of dorsal consonants.[33]

Dorsal consonant harmony is similarly attested in the Tepehua branch of the Totonacan family. In his description of **Tlachichilco Tepehua**, Watters (1988) discusses what he refers to as ‘k–q assimilation’ under the explicit heading ‘consonant harmony’ (which also covers an independent sibilant harmony process). Just as in Misantla Totonac, the assimilation is strictly anticipatory (right-to-left), such that a prefixal velar /k/ assimilates to a uvular /q/ or

lowering effect propagates through a sonorant (voiced?) lateral, but that it decreases in effect the further the vowel is from the uvular.

[33] A similar argument is made by Bessell (1998) for Interior Salish faucal harmony—an unbounded right-to-left vowel retraction harmony triggered by uvular and pharyngeal consonants (and thus an example of *vowel-consonant harmony*, as that term is used in this work). Bessell argues, based on acoustic measurements, that intervening consonants do not participate in faucal harmony, whereas vowels do so in a categorical manner. If Totonacan dorsal consonant harmony originated in a phonologization of local coarticulatory effects, Interior Salish may provide an interesting diachronic parallel. There are fundamental synchronic differences, however, in that the Totonacan phenomenon is a *consonant-consonant* interaction. Totonacan vowel lowering has all the hallmarks of a local, coarticulatory effect (following the criteria used by Bessell 1998). As will be seen below in the related Tlachichilco Tepehua, the consonant-consonant assimilation is independent of this effect and may apply across a span of segments where one or more intervening vowels are unaffected by lowering of any kind.

/q'/ in the following root, as illustrated in (22a).[34] Again like in Misantla Totonac, only certain prefixes fall within the domain of dorsal consonant harmony in Tlachichilco Tepehua, as the examples in (22a) vs. (22b) show, though the dichotomy between harmonizing and non-harmonizing prefixes does not seem to correlate with any obvious morphosyntactic or semantic properties.

(22) Tlachichilco Tepehua: dorsal consonant harmony (data from Watters 1988)

a. Harmony alternations in various prefixes and proclitics:

maqtʃaʔaːj	/mak-tʃaq'aː-j/	'X washes hands (impf.)'
maktʃaːj	/mak-tʃaː-j/	'X claps; cooks [tortillas] (impf.)'
ʔoqslaqts'in	/ʔuks-laqts'in/	'look at X across surface'
ʔuksk'atsaː	/ʔuks-k'atsaː/	'feel, experience sensation'
laqtʃeʔeɬ	/lak-tʃiq'i-ɬ/	'X broke them (perf.)'
lakhuniːɬ	/lak-huniː-ɬ/	'X told them (perf.)'
laqaːtʃaqaː	/lakaː=tʃaqaː/	[no gloss] (PREP-house)
lakaːk'iw	/lakaː=k'iw/	[no gloss] (PREP-tree)

b. No harmony in many prefixes (1Subj /k-/; 1Obj /kin-/; /kiː-/ 'return'):

k'aqtajniɬ	/k-'aqtaj-ni-ɬ/	'I began (perf.)'
kiʔaqsa	/kin-ʔaqs-a/	'it's tight on me'
kiːlaqts'iɬ	/kiː-laqts'i(n)-ɬ/	'X went, saw Y and returned (perf.)'

Note that the harmony is rendered opaque by a context-free debuccalization of ejective /q'/ (→ [ʔ]). As a result, the prefix /k/ in some of the (22a) examples appears to be 'harmonizing' with a glottal stop. The debuccalization of /q'/ is arguably a late postlexical process (see Watters 1988:536). It is bled by an optional, prosodically conditioned postlexical deglottalization, as seen in cases like [kaʔ̲amanantʃ'oʔ̲op'ut'unaːˈp'iːt'ik] ~ [kaq̲amanantʃoq̲oput'unaːˈp'iːt'ik] 'you (pl.) want to play again', where underlining indicates those instances of /q'/ which are alternately debuccalized to [ʔ] or deglottalized to [q] (depending on whether the postlexical deglottalization is applied or not). In any case, the triggering of dorsal agreement and lowering of adjacent vowels both betray the intrinsic uvularity of the consonant surfacing as [ʔ].

The examples in (22) all illustrate the workings of dorsal consonant harmony in heteromorphemic /k…q/ sequences, resulting in [k] ~ [q] alternations. Although Watters (1988) makes no explicit mention of whether the harmony holds within morphemes as well, this does seem to be the case. Moreover, there is direct evidence that harmony is actively enforced

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[34] Watters (1988) mentions two examples where harmony is rightward (/q…k/ → [q…q]), from prefix to root, both involving the body-part prefix /ʔaq-/ 'head': [ʔaqloqoti] 'horn' (/ʔaq-lukut/, cf. /lukut/ 'bone') and [ʔaqlaqawaːnan] 'dream' (from /lakaw/ 'see'). These exceptions are clearly of a sporadic nature, judging by numerous non-harmonized examples (e.g. [ʔaqʃkaviɬ] 'curly-headed' from /ʃkaviɬ/ 'curly').

root-internally. The Tlachichilco dialect imposes various constraints on syllable phonotactics, among them a requirement that a coda stop must be [dorsal]. By a process Watters refers to as 'consonant backing', underlying /t/ or /p/, whenever these end up in coda position, surface as [k] and [wk], respectively (the latter creates a diphthongal nucleus, [CVu̯k]). This is illustrated in (23a). Whenever a root like /q'ut-/ 'drink' is followed by a consonant or a word boundary, such that the root-final /t/ is syllabified as a coda, the expected outcome of coda dorsalization would be a disharmonic sequence *[q'uk…]. In such situations, the dorsalization process feeds dorsal consonant harmony: the derived coda dorsal surfaces as uvular [q], in harmony with the root-initial uvular (here /q'/); this is exemplified in (23b). (Recall from above that harmony is rendered opaque by the near-obligatory postlexical debuccalization /q'/ → [ʔ] in Tlachichilco Tepehua.)

(23) Tlachichilco Tepehua: coda dorsalization feeds harmony (Watters 1988)

a. Underlying /p, t/ dorsalize to [(w)k] in coda position:

ʃa.p'a	/ʃap-ʔa/	'X pants (imperf.)'
ʃawk.ɬi	/ʃap-ɬi/	'X panted (perf.)'

b. Dorsalized coda /p, t/ harmonizes with uvular /q, q'/ elsewhere in root:

ʔo.t'a	/q'ut-ʔa/	'X drinks it (imperf.)'	
ʔoq.ɬi	/q'ut-ɬi/	'X drank it (perf.)'	(not *[ʔok.ɬi])

Like in Totonac, uvulars in Tepehua have a lowering effect on neighboring high vowels (/i, u/ → [e, o]), as illustrated in (24a–b). This lowering, just like the dorsal consonant harmony, is made opaque by the postlexical debuccalization /q'/ → [ʔ], with the result that underlying /i, u/ appear to lower next to some surface [ʔ] but not others; cf. the near-minimal pairs in (24b) vs. (24c)

(24) Tlachichilco Tepehua: vowel lowering next to uvular /q, q'/ (Watters 1988)

a. Lowering of /i, u/ by non-ejective /q/:

qent'uj	/qin-t'uj/	'two (people)'
maqawe:qni	/maqawi:qni/	'swing (n.)'
ʔaqtʃoq	/ʔaq(-)tʃuq/	'pot'
ʔoqʃtama:ti	/ʔuqʃtama:-ti/	'hired worker'

b. Lowering of /i, u/ by ejective /q'/ (realized as [ʔ]):

laqtʃeʔej	/lak-tʃiq'i-j/	'X shatters Y (perf.)'
ʃʔe:w	/ʃq'i:w/	'yuca'
ʔoʃi	/q'uʃ(i)/	'good'
tsoʔo	/tsuq'u/	'bird' (cf. Huehuetla Tepehua [tsoq'o])

c. No lowering triggered by underlying /ʔ/ (also realized as [ʔ]):

laqts'iʔiːj	/laqts'in-ʔiː-j/	'X takes Y as an example'
ʃʔiːw	/ʃʔiːw/	'we (incl.) bought it'
ʔuʃ	/ʔuʃ/	'bee'

As for whether there might be a possible (synchronic) connection between vowel lowering and consonant harmony (both triggered by /q, q'/), such that the two are merely different manifestations of a single feature-spreading process, the answer is again negative. The counterevidence is even stronger in the Tlachichilco Tepehua case than in Misantla Totonac. Here, too, a uvular will only induce lowering in an *immediately* adjacent /i, u/; any intervening consonant blocks the process. Moreover, in cases where an intervening vowel is adjacent neither to the harmony trigger (the underlying uvular) nor to the harmony target (the derived uvular), that vowel is unaffected. This is shown in (25); the crucially non-lowered vowels are underlined.[35]

(25) Tlachichilco Tepehua: dorsal consonant harmony is not local spreading

a.	laqpu̲ː̲teʔenij	/lak-puːtiq'i-ni-j/	'X recounted it to them'
b.	ʔaqpi̲teʔej	/ʔak-pitiq'i-j/	'X folds it over'

The examples in (25) are strong evidence that Totonacan dorsal consonant harmony violates strict locality, enforcing agreement in uvularity across an intervening string of consonants and vowels, without also spreading the relevant feature/gesture to those intervening segments.

In addition to the Totonacan languages, another unambiguous example of dorsal harmony is found in the dialect of Aymara labelled **'Bolivian' Aymara** by MacEachern (1999). Unlike its Totonacan counterpart, dorsal consonant harmony in Aymara seems to hold only as a morpheme structure constraint. As MacEachern (1999) points out, velars and uvulars are not allowed to co-occur within roots, though each may combine freely with segments at other places of articulation. MacEachern's somewhat tentative observations, which were based on a search of de Lucca (1987), are limited to a few specific subtypes of disharmonic dorsal…dorsal sequences, /k^h…q^h/, /q^h…k^h/, /q^h…k'/ and /k'…q^h/; all of these she finds to be absent from roots. A detailed follow-up manual search of that same dictionary revealed that other combinations of velar and uvular stops (as well as fricatives; see below) are likewise prohibited or strongly disfavored in roots. The effects of dorsal consonant harmony in Bolivian Aymara are illustrated in (26).

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[35] The first morpheme in (25b) appears to be the body-part prefix 'head', which Watters (1988) analyzes elsewhere as containing an underlying uvular (/ʔaq-/; cf. n. 34 above). The (25b) example may thus turn out to be irrelevant in this context, as its uvular…uvular sequence would then be underlying rather than derived by harmony.

(26) ‘Bolivian’ Aymara: dorsal consonant harmony within roots

a. Well-formed sequences (data from de Lucca 1987)

qelqa	‘document’
q^{h}atʃq^{h}a	‘rough to the touch’
q’enq’o	‘rough (ground); crooked’
q^{h}apaqa	‘wealthy, rich person’
kiki	‘similar, identical’
k^{h}usk^{h}a	‘common’
k’ask’a	‘acid to the taste’
k’iku	‘wise’ (obsolete)

b. Unattested root-internal combinations[36]

*k^h…q^h	*k’…q’	*k…q	*k’…q^h	*k’…q	(etc.)
*q^h…k^h	*q’…k’	*q…k	*q^h…k’	*q’…k	(etc.)

It further appears that dorsal consonant harmony in Bolivian Aymara extends to fricatives as well. The only dorsal fricative in the inventory is uvular /χ/, which only occurs in word-medial position. A manual search for word-initial /KVχ…/ and /QVχ…/ sequences in de Lucca (1987)—where ‘K’ and ‘Q’ stand for any velar and uvular stop, respectively—reveals a great number of entries with /QVχ…/ (e.g. /qoχo/ ‘elbow’, /q’aχaɲa/ ‘dig’), but not a single entry with /KVχ…/. A few examples were found with /K…C…χ…/ where the velar and uvular are separated by one or more intervening consonants, but most of these seem likely to be polymorphemic.

Although the above description pertains only to the ‘Bolivian’ dialect of Aymara documented in de Lucca (1987), the co-occurrence restriction on velars and uvulars may well hold for Aymaran in general. This might be verified by conducting similar searches of Ayala Loayza (1988) or Deza Galindo (1989), both of which describe dialects that MacEachern (1999) labels ‘Peruvian’ Aymara.[37] Finally, at least one of the nearby (and perhaps distantly related) Quechuan languages appears to have the same kind of root-internal dorsal consonant harmony as (Bolivian) Aymara does. Mannheim (1991:173) points out that in modern **Southern Peruvian Quechua**, ‘a morpheme may have two velar stops or two uvular stops, but not

[36] De Lucca (1987) contains a few entries in which (plain) /q/ and /k/ co-occur, but most of these appear to be polymorphemic. Significantly, some have variant forms where dorsal consonant harmony has been enforced, such as [kamqota] ~ [qamqota] ‘beautiful’.

[37] As pointed out in §2.4.7, the ‘Bolivian’ and ‘Peruvian’ dialects differ slightly in the details of their laryngeal harmony restrictions (see MacEachern 1999). Unlike its Bolivian counterpart, Peruvian Aymara lacks /χ/ (and thus has no dorsal fricatives at all); a cross-dialectal comparison might shed light on the sources (or reflexes) of /χ/ and its participation in dorsal consonant harmony in Bolivian Aymara.

one of each'. Mannheim does not mention whether the same harmony is found elsewhere in the Quechuan family, such as in the Central Quechua branch.[38]

Based on Applegate's (1972) description, it appears that **Ineseño** Chumash may in the past have had a root-internal dorsal consonant harmony similar to that found in Aymara and Quechua. Applegate notes that velar /k/ and uvular /q, χ/ do not co-occur in the same CVC sequence (1972:35). He points out that velars and uvulars do frequently co-occur in what are synchronically single morphemes, but adds that '[i]t is tempting to regard these forms […] as having at one time been morphologically complex', noting that many appear to contain 'the ubiquitous formatives' /aq-/, /aχ-/. If Applegate's speculation is valid, then dorsal consonant harmony obtained in roots at an earlier stage of Ineseño, perhaps even Proto-Chumashan.

A gradient version of the exact same kind of root-internal dorsal consonant harmony has been found in the Tsimshianic language **Gitksan** (Brown 2008, Brown & Hansson 2008). Though there are many instances of roots in which velars and uvulars co-occur, these are statistically underrepresented (among all dorsal…dorsal co-occurrences) to a significant degree, with an Observed/Expected ratio of 0.57 for …C_xVC_y… contexts. The same effect is present at greater distances as well, with O/E = 0.66 for …C_x…C…C_y… contexts. By contrast, both velar…velar and uvular…uvular pairs are strongly overrepresented.

Finally, root-internal dorsal consonant harmony is also found in the Dravidian language **Malto**. According to Mahapatra (1979), velar /k, g/ and uvular /q, ʁ/ do not co-occur in CVC sequences (tautosyllabic, or heterosyllabic CV.CV), except where a morpheme boundary intervenes. Interestingly, this restriction is limited to dorsal obstruents; Mahapatra clearly states that velar /ŋ/ is free to co-occur with uvular /q, ʁ/ (Malto has no uvular sonorants). Though the description does not mention whether velars and uvulars can co-occur at greater distances, I was unable to find any such disharmonic long-distance sequences in what are plausibly single-morpheme forms in Mahapatra (1979).

In sum, dorsal consonant harmony does indeed exists, though it is not very common cross-linguistically. As for *labial* consonant harmony, on the other hand, no cases appear to be attested in adult language. Note that this term would refer to harmony interactions defined

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[38] Although Mannheim (1991) is concerned primarily with the Cuzco-Collao dialect of Southern Peruvian Quechua, there is no reason to doubt that his statement applies to the Ayacucho-Chanka dialect as well, where **q* > /χ/ in all positions such that the velar-uvular contrast is now manifested as /k/ vs. /χ/. Southern Peruvian Quechua belongs to the 'Peripheral Quechua' branch of the family (also known as Quechua A, or Quechua II). As for languages of the Central branch (Quechua B/Quechua I), Cerrón-Palomino (1977) makes no mention of co-occurrence restrictions on dorsal consonants in Wanka/Shausha, one of the subgroups of Central Quechua. This is perhaps not surprising, since **q* yields /ʔ/ in some dialects (Wanka), and /h ~ x/ in others (Shausha), such that any inherited dorsal consonant harmony between velars and uvulars would now be a matter of a restriction on the co-occurrence of /k/ with /ʔ/ or, alternatively, /k/ with /h ~ x/.

over some labial-specific distinction; the prime candidate being bilabials vs. labiodentals.[39] The absence of labial consonant harmony may have something to do with the fact that the bilabial–labiodental distinction is rarely utilized for phonological contrast in the world's languages. Labiodental articulation is typically restricted to fricatives; even among these, pure labiodental–bilabial contrasts are extremely rare (see Ladefoged & Maddieson 1996:16–18). The labiodental nasal [ɱ] is reasonably frequent, but is practically always allophonic, resulting from coarticulation of a (bi)labial nasal with an adjacent labiodental fricative. It should be noted that, with very few exceptions, the present survey finds that consonant harmony operates on phonologically *contrastive* distinctions. In light of this fact, and considering also the inherent aerodynamic problems involved in the articulation of labiodental stops (and to some extent nasals), the cross-linguistic absence of labial consonant harmony is hardly surprising.

One apparent case of such harmony has however been reported in child language (Stemberger 1988, 1993). In the speech of Gwendolyn (age 4;3–4;6), an otherwise bilabial /m/ regularly assimilated to a nearby labiodental [f] or [v], as illustrated in (27a). The examples in (27b) show that the 'spreading' of labiodentality is bidirectional, and that it operates across any number of intervening vowels (as well as across word boundaries).

(27) 'Labial consonant harmony' in child language? (Stemberger 1993)

a.	[lʌv ɱais]	'love mice'
	[snɪf ɱais]	'sniff mice'
b.	[fɱɛu ɱais]	'smell mice'
	[fɱɛu ɪɱ]	'smell him'
	[ɱai fɱɛui ɱais]	'my smelly mice'

Furthermore, the harmony extends across an intervening glottal [h] (28a), but is blocked by any other intervening consonant (28b).

(28) Transparent vs. opaque intervening segments

a.	[fɱau houɱ]	'small home'	
b.	[fɱau kʰoum]	'small comb'	(not *[fɱau kʰouɱ])
	[fɱaut mais]	'smart mice'	(not *[fɱaut ɱais])
	[fɱɛuz mais]	'smells mice'	(not *[fɱɛuz ɱais])
	[fɱɛuɪn mais]	'smelling mice'	(not *[fɱɛuɪn ɱais])

The opaque behavior of all buccal (i.e. non-glottal) consonants makes Gwendolyn's labial consonant harmony—if that is how it should be characterized—rather unusual in the context

[39] Another conceivable possibility would be (bi)labial vs. *linguo*labial, but given the extreme cross-linguistic rarity of segments of the latter type (Ladefoged & Maddieson 1996), it is hardly surprising that consonant harmony involving this contrast is unattested.

of the present typological survey. Segmental opacity effects are generally not observed in consonant harmony systems (though see §3.2.2.2 for some counterexamples), whereas glottal transparency is a very common pattern in 'vowel-consonant harmony' phenomena like nasal harmony (nasalization spreading). For example, a great number of nasal harmony systems surveyed by Walker (2000b) show nasalization spreading through vowels and glottals, and often glides as well (e.g. Acehnese, Barasano, Capanahua, Mixtec, Seneca, Sundanese, Urdu). It would seem clear that the harmony observed in Gwendolyn's speech involves feature *spreading* of some kind, whereas the formal analysis of chapters 4 and 5 below takes consonant harmony to be driven by constraints demanding featural *agreement* between highly similar segments. Nevertheless, the spreading vs. agreement dichotomy has turned out to be less clear-cut than previously assumed (e.g. by Hansson 2001b and Rose & Walker 2004), in that strictly-local feature spreading is one of the possible ways that non-local (i.e. long-distance) agreement can be satisfied (Hansson 2007b; see §3.2.2.2).

There are some intriguing aspects of the pattern in (27)–(28) which might suggest affinity with other types of consonant harmony, and with the analysis of such harmony as similarity-based agreement. In all of the examples cited by Stemberger (1988, 1993), it appears that long-distance labiodentalization of nearby nasals is fed by a local assimilation in /f, v/ + /m/ clusters (→ [fɱ, vɱ]). We see no cases where a lone /f/ or /v/ *directly* triggers long-distance assimilation in a nearby /m/, across intervening vowels (e.g. in '<u>f</u>oa<u>m</u>', '<u>m</u>o<u>v</u>e', or a phrase like '<u>m</u>y <u>f</u>oot'). If the data are representative, and /m/ is unaffected in such cases, then the long-distance assimilation observed in Gwendolyn's speech could be characterized as an agreement in labiodentality among labial *nasals*. Unfortunately, according to Joseph Paul Stemberger (pers. comm.) the original notes from the period at which Gwendolyn exhibited this harmony contain no transcribed instances of the kinds of words and phrases that would help decide the matter. His own tentative recollection is that the phenomenon was probably only observed in utterances which contained /fm/ and /vm/ clusters, and not otherwise—in other words, that a word like 'foam' would have been pronounced as [foum], not [fouɱ]—but as two decades have passed since that time, such recollections cannot be relied upon.[40] Given the ephemeral nature of child language data, we will never know exactly what the true nature of Gwendolyn's 'labial consonant harmony' was, nor how it might relate to the kinds of harmony patterns observed in adult language.

2.4.3. Secondary-Articulation Harmony

The class of secondary articulations is conventionally assumed to include at least labialization, palatalization, velarization and pharyngealization (and perhaps 'uvularization' as well, following Shahin 2002; see n. 42 below). A secondary articulation can be viewed as the su-

[40] It may be relevant in this context that the harmony only started appearing when Gwendolyn stopped rendering adult /sm/ clusters as [m̥] and started producing them as [fɱ] instead (Stemberger 1988:57).

perimposition of an essentially vocalic constriction onto a consonant. What this means in representational terms is a matter of some controversy (see Clements & Hume 1995 and references cited therein), but the precise phonological status of secondary-articulation features will not be of direct relevance here. The issue at hand is whether consonant harmony ever involves assimilation in secondary-articulation properties. As it turns out, a few cases of this type do exist. All are discussed at length in Hansson (2007c), to which the reader is referred for more details.

The most remarkable case is the curious sibilant pharyngealization harmony exhibited by the Northern Athapaskan language **Tsilhqot'in** (**Chilcotin**; Krauss 1975, Cook 1983, 1987, 1993, Andrews 1988, Hansson 2007c). In the Tsilhqot'in consonant inventory, the so-called 'flat' (pharyngealized) alveolar sibilants /sˤ, zˤ, tsˤ, ts'ˤ, dzˤ/ contrast with 'sharp' (i.e. non-pharyngealized) /s, z, ts, ts', dz/. The contrast is generally not clearly perceptible on the sibilants themselves (Krauss 1975, Latimer 1978, Cook 1993), but is easily detectable through the effects flat sibilants have on neighboring vowels. In the vicinity of a flat sibilant, vowels are systematically lowered and/or retracted ('flattened'; e.g. /i/ → [əi ~ e], /ɛ/ → [ʌ], /æ/ → [ɑ]). In addition to these two series of alveolar sibilants, Tsilhqot'in also has a third sibilant series, lamino-postalveolar /ʃ, tʃ, tʃ', dʒ/, which are phonetically more or less identical to their English counterparts (though /ʃ/ seems to be realized as dorso-palatal [ç] in word-final position). The postalveolar sibilants do not have any effect on nearby vowels; they are also entirely neutral and transparent to the sibilant pharyngealization harmony.[41]

The pharyngealization contrast in sibilants, and the allophonic alternations it triggers in neighboring vowels, has typically been analyzed in terms of the feature [±Retracted Tongue Root], and sibilant pharyngealization harmony is thus a matter of agreement in [±RTR] among alveolar sibilants within the word (Cook 1993). Synchronically, the effects of this [±RTR] agreement are obscured somewhat by a separate process of unbounded leftward [+RTR] spreading, which emanates from a pharyngealized sibilant and affects every preceding vowel in the word (and perhaps intervening consonants as well, though this is harder to detect). This unbounded spreading, as well as the local 'flattening' of an immediately following vowel, is illustrated in (29). Here and in subsequent examples, underlining serves to highlight those vowels which are retracted and/or lowered due to a nearby [+RTR] consonant (including the uvulars, or 'back velars', which are also interpreted as being [+RTR]). Note that

[41] Gafos (1999) interprets the distinction between 'sharp' and 'flat' sibilants as a dental-alveolar vs. lamino-postalveolar contrast, and takes the neutral /ʃ/-series sibilants to be true dorso-palatals (in all positions). On this interpretation, Tsilhqot'in consonant harmony is a straightforward case of coronal sibilant harmony, closely resembling its (cognate) counterparts in other Athapaskan languages such as Tahltan or Navajo. Unfortunately, this interpretation is not consistent with the phonetic facts of Tsilhqot'in (on which see Hansson 2007c: 97–98, 104–105), though it is almost certainly true that the sibilant pharyngealization harmony of Tsilhqot'in developed *historically* out of what was previously a more typical coronal harmony system, probably based on a dental vs. alveolar contrast (Hansson 2007c).

tone is not marked in any of the examples cited here, as it has generally not been indicated in the sources consulted.

(29) Tsilhqot'in: [+RTR] spreading (vowel 'flattening') triggered by /sˤ/, /zˤ/, etc.

a. /gʷɛ-nɛ-tɛ-ʁɛ-zˤɛɬ/ [g̊ʷʌ̱nʌ̱ntʰɑ̱zˤʌ̱ɬ] 'it is going to get warm'

b. /ʔæ-næ-tɛ-sˤɛ-id-t'in/ [ʔɑ̱nɑ̱tʰʌ̱zˤə̱i̱t'in] 'we started working'
(cf. /ʔæ-næ-dʒɛ-t'in/ → [ʔænæd̥ʒɛt'in] 'they are working')

Sibilant pharyngealization harmony, by contrast, simply enforces agreement in [±RTR] between all alveolar sibilants in a word. The harmony is anticipatory: the rightmost sibilant determines the [±RTR] value of any and all preceding (alveolar) sibilants in the word. When the harmonizing feature value is [+RTR]—that is, when the rightmost of the sibilants is pharyngealized—the effect of this consonant harmony is rendered invisible by the general right-to-left [+RTR] spreading shown in (29), as illustrated in (30a). However, the *de*pharyngealizing version of the consonant harmony, where the triggering (i.e. rightmost) sibilant is [−RTR], is readily detectable. In the forms shown in (30b), sibilant harmony depharyngealizes the [sˤ] (or [zˤ]) of the conjugation marker /sˤɛ-/, and hence has the effect of *bleeding* the spread of [+RTR] from that sibilant to nearby vowels (as was seen in (29b) above).

(30) Tsilhqot'in: sibilant pharyngealization harmony (see Hansson 2007c)

a. [+RTR] version: obscured by unbounded [+RTR] spreading
/næ-sɛ-næ-ʁɛ-nɛ-l-tsˤɛnsˤ/ [nɑ̱sˤʌ̱nɑ̱ʁə̱̃ĩ̱ltsʰˤʌ̱̃sˤ] 'you're hitting me'
/næ-nɛ-dɛ-ʁɛ-s-ɬ-bæsˤ/ [nɑ̱nʌ̱d̥ɑ̱sˤb̥ɑ̱sˤ] 'I'm turning you around'
(cf. /næ-nɛ-dɛ-ʁɛ-s-ɬ-gæɬ/ [nænɛd̥æsg̊æɬ] 'I'm spinning you')

b. [−RTR] version: bleeds unbounded [+RTR] spreading
/næ-tɛ-sˤɛ-s-d-bin/ [nætɛzɛsb̥in] 'I'm swimming away'
(cf. /næ-tɛ-sˤɛ-id-d-bin/ [nɑ̱tʌ̱zˤə̱i̱b̥in] 'we're swimming away')
/sˤɛ-i-ɬ-tʃæz/ [siɬtʃʰæz] 'I barbequed it'
(cf. /jæ-sˤɛ-id-ɬ-tɪg/ [jɑ̱sˤə̱i̱ltʰɪg̊] 'we're not talking')

The second example in (30b) illustrates the fact an intervening lamino-postalveolar sibilant (here [tʃ]) neither blocks harmony nor interacts with it in any way. More generally, any and all intervening segments are transparent to sibilant pharyngealization harmony. That this harmony is not a matter of strictly-local spreading of articulatory gestures or phonological features is demonstrated most clearly by forms like the ones shown in (31) (taken from my own field notes from 2000). Here, anticipatory agreement in [−RTR] holds across a span which includes vowels that are surfacing as [+RTR] (due to local assimilation to an immediately adjacent uvular fricative [ʁ]). The interacting sibilants are indicated in boldface, and the (locally) retracted vowels are underlined.

(31) Tsilhqot'in: anticipatory [–RTR] harmony across [+RTR] segments

a. /ɬæ jɛ-tɛ-**s**ˤɛ-ʁæ-id-jɛ**z**/ [ɬæ jɛtʰɛ**z**ʌ̠ʁɑ̠d̥ʒɛ**z**]
'we're not going to get the hiccups'

b. /ɬæ næ#tɛ-**s**ˤɛ-ʁæ-id-l-k'ɛ**s**/ [ɬæ nætʰɛ**z**ʌ̠ʁɑ̠lk'ɛ**s**] (speaker A)
'we're not going to be stiff' [ɬæ nætʰɛ**z**ɑ̠lk'ɛ**s**] (speaker B)

Were it not for sibilant (de)pharyngealization harmony, the forms in (31) should surface as [jʌ̠tʰʌ̠zˤʌ̠ʁɑ̠d̥ʒɛz] and [nɑ̠tʰʌ̠zˤʌ̠ʁɑ̠lk'ɛs] ~ [nɑ̠tʰʌ̠zˤɑ̠lk'ɛs], respectively—with the [zˤ] of the /sˤɛ-/ prefix remaining pharyngealized, and in turn spreading its [+RTR] specification to all preceding (and immediately following) vowels. The fact that [–RTR] consonant harmony is capable of applying across intervening [+RTR] vowels is clear evidence that Tsilhqot'in sibilant harmony involves long-distance *agreement* in the [±RTR] feature, rather than (local) spreading.[42]

Another example of secondary-articulation consonant harmony is (labio)velarization agreement in **Pohnpeian** (Ponapean; Rehg & Sohl 1981, Mester 1988a, 1988b, Hansson 2007c), which is manifested as a static co-occurrence restriction on roots. In Pohnpeian, a pure velarization contrast exists only for labial consonants: plain /p, m/ contrast with velarized /pˠ, mˠ/. The latter are more typically represented as 'pʷ' and 'mʷ' in the literature, reflecting the fact that velarization in labials is accompanied by lip rounding in most, though not all, environments (for example, not in word-final position). The labialization component appears to be a matter of secondary phonetic enhancement in these particular segments, whereas velarization as such plays a much more central and active role in Pohnpeian phonology (see below). The essence of the consonant (labio)velarization harmony is that in any given Pohnpeian morpheme, plain and velarized labials are not allowed to co-occur, as shown in (32).[43] McCarthy (1989:79), who refers to the Pohnpeian phenomenon as a 'rounding harmony' in labials, finds the same co-occurrence restrictions to be in effect in the closely related **Mokilese** as well.

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[42] Shahin (2002) argues that *uvularization* and *pharyngealization* are distinct phenomena, with different (though somewhat overlapping) phonetic manifestations. One might perhaps argue that sibilant pharyngealization harmony can hold across a 'uvularization' span. There are two reasons for rejecting this idea. One is the fact that uvulars and pharyngealized sibilants have the exact same categorical effects on vowel quality (e.g. [æ] → [ɑ], [i] → [ʌi]). The second objection is that in (31), it is contrastive *non*-pharyngealization that is being extended across the local uvularization span. Even if pharyngealization and uvularization are distinct and to some extent independent phenomena, it seems obvious that active *de*pharyngealization and active uvularization are inherently incompatible.

[43] Mester (1988b) attributes this generalization to Rehg & Sohl (1981:44–46), but notes that the latter only discuss the incompatibility of /m/ with /mˠ/ and of /p/ with /pˠ/. As Mester (1988b:21, n. 2) points out, the other combinations in (32b) appear to be unattested as well.

(32) Pohnpeian: root-internal (labio)velarization harmony in labials (Rehg & Sohl 1981)

a. Well-formed roots

pirap	'steal; be stolen'
mem	'sweet'
parem	'nipa palm'
matep	'species of sea cucumber'
pˠupˠ	'fall down'
mˠaːmˠ	'fish'
mˠopˠ	'out of breath'

b. Unattested combinations within (native) roots

*p…pˠ	*m…mˠ	*p…mˠ	*m…pˠ
*pˠ…p	*mˠ…m	*pˠ…m	*mˠ…p

As illustrated by examples such as /matep/ and /parem/ in (32a), the harmony is not sensitive to the segmental material which intervenes between the two labials. There are no particular segments (consonants and/or vowels) which are opaque, blocking the propagation of harmony, and which would thus allow a velarized and non-velarized labials on either side to co-occur with each other.

In general, all the consonants of Pohnpeian can be classified as either 'front' or 'back'. The latter class, which comprises /pˠ, mˠ, ʈʂ, r, k, ŋ/, triggers retraction in adjacent vowels, due to the fact that these consonants are all phonetically velarized: [pˠ, mˠ, ʈʂˠ, rˠ, k(ˠ), ŋ(ˠ)]. The 'front' consonants /p, m, t, s, l, n/, on the other hand, are not velarized, and do not have any such effect on vowels. Rehg & Sohl (1981) also note the morpheme-level incompatibility (or near-incompatibility) of other pairs of 'front' and 'back' consonants that are highly similar but do not minimally contrast in velarization alone: the two liquids /l/ vs. /r(ˠ)/, the two plosives /t/ vs. /ʈʂ(ˠ)/, and the non-labial nasals /n/ vs. /ŋ(ˠ)/. Though they are clearly all connected, and seem to revolve around *velarization* rather than the other features distinguishing the segment pairs in question, these additional co-occurrence restrictions in Pohnpeian have been noted separately in this survey, each in the relevant section: non-sibilant coronal harmony (§2.4.1.2 above) for dental /t/ vs. retroflex /ʈʂ(ˠ)/, liquid harmony (§2.4.5) for lateral /l/ vs. rhotic /r(ˠ)/, and 'major-place harmony' (§2.4.8) for dental /n/ vs. velar /ŋ(ˠ)/.

The co-occurrence restrictions on velarized and non-velarized consonants in Pohnpeian could potentially be viewed as reflecting a general *similarity avoidance* effect (Frisch et al. 2004): the co-occurrence of highly similar but non-identical consonants is disfavored or banned (/l…r(ˠ)/), whereas that of less similar pairs (/n…r(ˠ)/) or of totally identical ones (/r(ˠ)…r(ˠ)/, /l…l/) is not disfavored (at least not to the same degree). However, the patterning of the labials in (32) does not quite fit this simple generalization: while */mˠ…p/ is banned, /mˠ…pˠ/ is allowed, even though the latter are even more similar than the former (without being fully identical). In this respect, the velarization 'agreement' in Pohnpeian labials more closely resembles a genuine (root-internal) consonant harmony. This is parallel to cases like sibilant harmony in Basque, or laryngeal harmony in Ijoid languages (on which see §2.4.7 below), in which highly similar but *non-agreeing* pairs like */s…tʃ/ or */ɗ…b/ are banned, but even more similar (and non-identical) *agreeing* pairs like /ʃ…tʃ/ or /ɗ…ɓ/ are permitted.

As for consonant palatalization harmony, only one case appears to be attested, the highly endangered Turkic outlier language **Karaim** (Kowalski 1929, Jakobson et al. 1963, Musaev 1964, Lightner 1965, Hamp 1976, Nevins & Vaux 2003, Denwood 2005, Hansson 2007c), specifically the Northwestern dialect, spoken around Trakai, Lithuania (Kowalski 1929). Historically speaking, Northwest Karaim has 'transphonologized' its inherited Turkic palatal (i.e. front/back) *vowel harmony* system into a consonant-based one. 'Frontness' has become a contrastive property of consonants rather than of vowels, and all consonants within a word (other than /j/) are required to agree in palatalization ([kʰʲozʲ-lʲɑrʲ-imʲ-dʲɑnʲ] 'from my eyes' vs. [ɑt-lˠɑr-ɯm-dɑn] 'from my horses'; cf. the corresponding Turkish cognates [g<u>ø</u>z-l<u>e</u>r-<u>i</u>m-d<u>e</u>n] vs. [<u>ɑ</u>t-l<u>ɑ</u>r-<u>ɯ</u>m-d<u>ɑ</u>n]). There is no question that this transposing of the 'palatality' contrast from vowels onto consonants is directly due to the fact that Karaim has been embedded in a Baltic- and Slavic-speaking environment and subject to extensive language contact persisting over many centuries.

There is some controversy as regards the question whether Northwest Karaim should be classified as a genuine *consonant* harmony system (see Hansson 2007c). There is still some residue of front vs. back vowel contrasts (/e/ contrasts with /ɑ/ in initial syllables, and /y, ø/ contrast with /u, o/ in absolute word-initial position), and /i/ is realized as front [i] or back [ɯ] depending on the palatalization of adjacent consonants. Likewise, the back vowels /ɑ, o, u/ are typically somewhat fronted (or at least centralized) next to a palatalized consonant.[44] For this reason, some authors have viewed Karaim as exhibiting a 'syllabic harmony' system, whereby entire syllables are characterized as [+back] or [–back], and where that feature is manifested on consonants and vowels alike (Musaev 1964, Csató & Johansson 1996, Csató 1999, Denwood 2005).

There are good reasons for rejecting the notion that harmony in Northwest Karaim targets vowels and consonants equally, and for viewing it as palatalization agreement among consonants specifically, as has been done here. First of all, even Musaev (1964), who advocates a 'syllabic harmony' interpretation, acknowledges that /ɑ, o, u/ are fully back in front-harmonic words (e.g. [kʲʰozʲ] 'eye') for younger speakers, whose pronunciation is even more strongly influenced by Lithuanian and Russian phonology; such speakers have also replaced word-initial /y, ø/ with /ju, jo/—again with fully back vowels, even though such words remain

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[44] This is hardly surprising, given that the acoustic cues for vowel frontness and consonant palatalization inevitably overlap a great deal in the speech signal, creating some ambiguities of localization. In many Turkic languages with palatal vowel harmony, consonants exhibit coarticulatory palatalization in front-harmonic words (Waterson 1956; cf. Ní Chiosáin & Padgett 1997, 2001). Conversely, in Baltic and Slavic languages, where palatalization is phonemic on consonants, coarticulatory fronting in adjacent vowels is one of the strongest acoustic cues to consonant palatalization (Derkach 1975, Evans-Romaine 1998).

front-harmonic with respect to consonant palatalization. Secondly, Nevins & Vaux (2003) examine the acoustics of Karaim vowels in recordings from Csató & Nathan (2002) and find many instances of fully back vowels in C^{j}VC^{j} sequences. This is especially true in word-initial and word-final syllables (e.g. [k^{jh}ot^{j}-ʉɾ-ʉl^{j}-g^{j}un^{j}] ‘lift yourself up’), where the greater vowel duration provides less opportunity for centralization as an effect of target undershoot. It seems clear, then, that palatalization is ‘transmitted’ from consonant to consonant, across an intervening vowel, without the feature in question *necessarily* targeting that vowel (and perhaps never doing so, from the perspective of the phonological surface representation).

A possible though far less persuasive case of consonant palatalization harmony is **Zoque** (Wonderly 1951). When discussing various local palatalization effects of the glide /j/ on neighboring consonants, Wonderly (1951:117) cites, among others, the two forms /sohs-jah/ → [ʃohʃahu] ‘they cooked it’ (from /sohs-/ ‘cook’) and /meʔts-jah/ → [m^{j}eʔtʃahu] ‘they sought it’ (from /meʔts-/ ‘seek’).[45] He does not comment on the double ‘palatalization’ in these forms. Other similar forms do not show the same effect, e.g., /ken-jah/ → [keɲahu] ‘they looked’ (from /ken-/ ‘see’) and /wiht-jah/ → [wihtʃahu] ‘they walked’ (from /wiht-/ ‘walk’), even though /k/ and /w/ regularly undergo palatalization when immediately adjacent to /j/. In the absence of more data it is thus impossible to know how the Zoque facts are to be interpreted. It should also be noted that even if the Zoque data genuinely reflect consonant harmony of some kind, more information would be needed to determine whether this should be classified as true *palatalization* harmony or, instead, as a kind of coronal harmony (involving the alveolar vs. postalveolar contrast), or perhaps a combination of the two. In some respects, Zoque seems to resemble the other cases of ‘morphological palatalization’ that have been mentioned in earlier sections, such as in Chadic (Miya, Gude, Mafa; see §2.4.1.1) and Ethio-Semitic (Harari; §2.4.1.2), where the affix-induced ‘palatalization’ may target two or more base segments.

Before setting aside the category of secondary-articulation consonant harmony, it is interesting to note that of the three (relatively) unambiguous cases of this extremely rare phenomenon (Tsilhqot’in, Pohnpeian, Northwest Karaim), two have arisen through the transposing of a harmony system of a more ‘standard’ kind into the dimension of secondary-articulation contrasts: Tsilhqot’in and Northwest Karaim. In both cases, an important contributing factor in this ‘transphonologization’ has been language contact: areal influence from (or at least convergence with) nearby unrelated languages with significantly different phonological inventories. In Tsilhqot’in, an inherited coronal harmony of a well attested kind (§2.4.1.1)—based in a dental vs. alveolar contrast (which in turn reflected an even earlier alveolar vs. postalveolar sibilant contrast)—has morphed into a highly unusual ‘sibilant

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[45] Wonderly writes a cluster (‘my’) in the latter case, but I follow Sagey (1990) and Humbert (1995) in interpreting such ‘Cy’ combinations as palatalized (e.g. [m^{j}]). However, Wonderly is very explicit in defining the ‘palatalized’ counterparts of /s/, /ts/, etc. as being ‘alveo-palatal’ (i.e. lamino-postalveolar) [ʃ], [tʃ], and so forth; they are definitely not [s^{j}], [ts^{j}] (*pace* Humbert 1995).

pharyngealization harmony'. Though it might seem drastic, this change is merely an incidental by-product of the shift of the inherited dental vs. alveolar contrast into a pharyngealized vs. non-pharyngealized alveolar contrast, under areal influence from nearby Salish languages (Cook 1993:150, Hansson 2007c). In Northwest Karaim, an inherited palatal vowel harmony system has morphed into a unique system of consonant palatalization harmony (Nevins & Vaux 2003). Again, this seemingly radical change is the by-product of a contact-induced shift in the locus of phonemic 'palatality' contrasts from vowels to consonants, modelled after the phonologies of surrounding Baltic and Slavic languages. (For more details on the diachronic aspects of secondary-articulation harmony in Tsilhqot'in and Karaim, see Hansson 2007c.)

2.4.4. Nasal Consonant Harmony

Another phonetic parameter along which consonant harmony may operate is nasality. Following Hyman (1995), this will here be referred to as 'nasal consonant harmony', in contradistinction to the more familiar (and much more widespread) phenomenon of 'nasal harmony'. In the latter, nasalization spreads leftward and/or rightward to any and all (nasalizable) segments that fall within the domain of spreading. For a typological study of nasal harmony systems, see Walker (2000b).

Nasal harmony (i.e. nasalization spreading) is illustrated in (33) with examples from Johore Malay (Onn 1980, cited from Walker 2000b). In Johore Malay, nasalization spreads rightwards from a nasal consonant, affecting vowels and glides. Harmony is blocked by all supralaryngeal consonants (liquids and obstruents), whereas glottals are transparent. In the transcriptions in (33), the permeability of glottals is indicated by marking them as nasalized as well (on nasalization in glottals, see Walker & Pullum 1999); triggering nasals are shown in boldface, and affected vowels and glides are underlined.

(33) Nasal harmony in Johore Malay (Onn 1980)

mã̲j̲̃ã̲ŋ	'stalk (palm)'
mə̲̃**n**ã̲w̲̃ã̲n	'to capture (active)'
mã̲ʔ̲̃ã̲p	'pardon'
pə**n**ə̲̃**ŋ**ã̲h̲̃ã̲n	'central focus'
pə**ŋ**ã̲w̲̃ã̲san	'supervision'
mə̲̃ratappi	'to cause to cry'

Nasal *consonant* harmony, by contrast, does not affect intervening segments in any phonetically obvious way: it does not result in the nasalization of any vowels (or consonants) separating the trigger and target consonant. Cross-linguistically, nasal consonant harmony appears to be fairly rare—certainly much rarer than nasal harmony—but it is well attested within one language family: the Bantu languages of sub-Saharan Africa. In those Bantu languages that have nasal consonant harmony, it is typically manifested in suffix alternations, such that a suffixal consonant which normally surfaces as [l], [d] or [r] is replaced by nasal [n] if preceded by a nasal earlier in the stem (Greenberg 1951, Johnson 1972, Howard 1973, Ao 1991, Odden 1994, Hyman 1995, Piggott 1996, Walker 2000b, 2000c).

The most dramatic instantiation of Bantu nasal consonant harmony is that found in languages such as **Mbundu** (Kimbundu; Chatelain 1888–1889), **Kongo** (Kikongo; Ao 1991, Odden 1994, Piggott 1996) and **Yaka** (Kiyaka; Hyman 1995), where harmony holds regardless of the distance between the trigger and target consonants.[46] This is illustrated by the Yaka forms in (34), cited from Hyman (1995); the transcription has been adjusted to IPA. In (34a), harmony can be seen operating across a vowel, while in (34b), the interacting consonants are further apart.

(34) Yaka: nasal consonant harmony alternations (Hyman 1995)

a. Harmony alternations in perfective suffix /-ili/:[47]

-són-ene	'color'	(cf. [-sól-ele] 'deforest')
-kém-ene	'moan'	(cf. [-kéb-ele] 'be careful')
-ján-ini	'cry out in pain'	(cf. [-jád-idi] 'spread')
-tsúm-ini	'sew'	(cf. [-tsúb-idi] 'wander')

b. Interaction at a distance:

-mák-ini	'climb'
-ɲéːk-ene	'bend down'
-hámúk-ini	'break (intr)'
-nútúk-ini	'bow'
-míːtuk-ini	'sulk'

As the forms in (34b) clearly show, intervening consonants do not interfere with the 'agreement' in nasality in any way. Interestingly enough, this is even true of intervening NC sequences. These might either be analyzed as singleton complex segments (i.e. prenasalized stops) or as nasal-stop clusters (see Rose & Walker 2004 for discussion). As shown in (35a), prenasalized stops do not trigger harmony in a following /l/; moreover, forms such as those in (35b) show that nasal consonant harmony holds *across* a prenasalized stop. As in (34) above,

[46] Note that 'Mbundu' here refers to **KiMbundu** rather than the closely related **UMbundu**. The latter also displays a phenomenon closely resembling the nasal consonant harmony of other Bantu languages (and presumably cognate with it; see Dolbey & Hansson 1999). UMbundu is quite different, in that intervening vowels *are* nasalized. Furthermore, the 'harmonization' of /l/ yields not [n] but a segment transcribed as [l̃]; /k/ is also nasalized, yielding [h̃]. See Schadeberg (1982) for detailed discussion of the complex nasalization patterns found in UMbundu.

[47] The [i]~[e] suffix alternations are due to vowel height harmony. The distribution of [d] vs. [l] is allophonic, with [d] appearing before the high front vowel [i] (and in NC clusters), otherwise [l]; the relevant phoneme is here represented underlyingly as /l/.

all forms contain perfective /-ili/, which surfaces as [-idi] or [-ele] when unaffected by harmony.

(35) Yaka: inertness of prenasalized stops (Hyman 1995)

a. NCs are non-triggers:

-bíːmb-idi	'embrace'	(not *[-bíːmb-ini])
-kúːnd-idi	'bury'	(not *[-kúːnd-ini])
-héːŋg-ele	'sift'	(not *[-héːŋg-ene])

b. NCs are transparent:

-náːŋg-ini	'last'
-núːŋg-ini	'win'
-méːŋg-ene	'hate'

Many other Bantu languages have a much more restrictive version of nasal consonant harmony than do Yaka and Kongo. In such systems, harmony is strictly *transvocalic* in that it only applies when the triggering nasal is separated from the target by no more than one vowel. Given the general CV syllable structure of the languages in question, another conceivable formulation of this proximity restriction would be that the trigger and target are required to be in adjacent syllables (Odden 1994, Piggott 1996, Walker 2000c, Rose & Walker 2004; see §3.2.2.3 for discussion of this issue). As illustrated in (36), nasal consonant harmony is limited to transvocalic contexts in **Lamba** (Chilamba; Doke 1938, Odden 1994).

(36) Lamba: transvocalic nasal consonant harmony (Odden 1994)

a. Perfective suffix /-ile/:

-pat-ile	'scold (perf.)' (Piggott 1996:142)	
-uum-ine	'dry (perf.)	
-nw-iːne	'drink (perf.)'	
-mas-ile	'plaster (perf.)'	(not *[-mas-ine])

b. Transitive reversive suffix /-ulul-/:

-fis-ulul-a	'reveal'	
-min-unun-a	'unswallow'	
-mas-ulul-a	'unplaster'	(not *[-mas-unun-a])

c. Intransitive reversive suffix /-uluk-/:

-fis-uluk-a	'get revealed'	
-min-unuk-a	'get unswallowed'	
-mas-uluk-a	'get unplastered'	(not *[-mas-unuk-a])

As the last example in each of (36a–c) shows, the root-initial /m/ of /mas-/ 'plaster' does not trigger assimilation in a suffixal /l/, unlike the root-initial /n/ of /nw-/ 'drink' in (36a). The harmony requirement holds only when the trigger and target consonants are separated by no more than one vowel (syllable nucleus).

Other Bantu languages where nasal consonant harmony follows the same transvocalic pattern are **Ila** (Chiila; Greenberg 1951), **Bemba** (Chibemba; Hyman 1995, Kula 2002), **Luba** (Tshiluba; Johnson 1972, Howard 1973), **Ndonga** (Oshindonga; Viljoen 1973, Tirronen 1986, Walker 2000c), **Tonga** (Chitonga; Collins 1975), **Herero** (Otjiherero; Booysen 1982) and **Kwanyama** (Oshikwanyama; Meinhof 1932). According to Larry Hyman (pers. comm.), other languages that can be added to this list include **Pende** (Kipende), **Punu** (Yipunu) and **Ruund**, though Ruund seems to be in the progress of levelling harmony alternations in favor of the [-Vn(V)-] alternant.[48] Yet another language, **Suku** (Kisuku; Piper 1977), is intermediate between the 'transvocalic' and 'unbounded' types, in that a /-Vl(V)/ suffix is optionally harmonized to a root-final nasal when another -VC- suffix intervenes.

In languages like the abovementioned ones, in which nasal consonant harmony is manifested overtly through alternations, harmony holds as a root-internal co-occurrence restriction as well. Hyman (1995) goes so far as to reduce the Yaka sound pattern to a general constraint banning (non-prenasalized) voiced oral consonants from occurring if preceded by a nasal anywhere within the stem (where 'stem' covers the root and any suffixes). Piggott (1996) makes a similar observation about Kongo, based on a search of Bentley (1887) and Laman (1936). The same appears to be true of the strictly transvocalic harmony in Lamba as well. Hyman (1995:23) suggests that other Bantu languages may have an even more limited version of nasal consonant harmony, such that it exists solely as a root-level restriction; in such a language, we would find Proto-Bantu **-mid-* 'swallow' > /-min-/, but **-túm-id-* 'send for' > /-túm-id-/ (or /túm-il-/, or /túm-ir-/).

It should be noted that among roots, only those with the structure -NVD- harmonize consistently (to -NVN-), whereas -DVN- roots are typically not harmonized ('N' = any full nasal, 'D' = any voiced oral consonant). Bantu nasal consonant harmony thus appears to be inherently directional, operating exclusively by means of progressive (perseveratory, left-to-right) assimilation in [+nasal]. The issue of directionality in Bantu nasal consonant harmony will be taken up again in §3.1.3 and §4.3.3 below. Interestingly, diachronic evidence suggests that nasal consonant harmony has occasionally applied bidirectionally within the root domain (see $3.1.3). Most strikingly, the Proto-Bantu root **-bon-* 'see' has become /-mon-/ throughout a large area that coincides almost perfectly with the geographic area where (progressive) nasal consonant harmony between root and suffixes is found.[49] The systematicity of the correlation suggests that this case of regressive (anticipatory, right-to-left) assimilation is more than a

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[48] If Greenberg's (1951) description is accurate, nasal alternants have also been generalized in **Fang**; thus the applicative suffix is [-in-] regardless of context, and reversive is [-un-].

[49] I am grateful to Larry Hyman for bringing this correlation to my attention. The only exception I have come across is Tonga (Collins 1975), which shows (transvocalic) harmony in suffixes, as well as root-internally in /-men-/ 'swallow' (< **-mid-*) and the like, but has retained unharmonized /-bon-/ 'see'.

sporadic quirk. In addition, anticipatory nasal consonant harmony holds between suffix and stem in at least one Bantu language, **Pangwa** (Kipangwa; Stirnimann 1983). Here, reciprocal /-an-/ triggers nasalization in a stem-final velar ([-pulix-] 'listen to' [-puliŋ-an-] 'listen to each other').

Another Bantu language, **Ganda** (Luganda; Katamba & Hyman 1991) seems to display a root-level nasal consonant harmony that is to some extent dependent (or 'parasitic') on place of articulation. In canonical C_1VC_2 roots, C_1 and C_2 are required to agree in nasality if they are homorganic and voiced; that is, *NV(:)D and *DV(:)N are banned when N and D have the same place of articulation. In addition, there is a marked dispreference for *NV(:)D sequences in general, even when N and D are non-homorganic, though the situation is more complicated there. The only robustly occurring combinations of this type are mVD and ɲVg (both with a short vowel); by contrast, *ɲVD (D ≠ /g/), *nVD and *NV:D are all disallowed. Katamba & Hyman (1991:201) surmise that the Ganda co-occurrence restrictions on nasality can largely be reconstructed back to Proto-Bantu. The protolanguage does not seem to have allowed any morpheme-internal /d…n/ sequences, and few /b…m/ sequences (if any). Nonhomorganic sequences like /d…m/ or /b…n/, on the other hand, were quite frequent in the Proto-Bantu lexicon. Interestingly, at least one Proto-Bantu /n…n/ root (**-nun-* 'old person') has cognates with /d…n/ in some of the related Grassfields (Bantoid) languages (Larry Hyman, pers. comm.), suggesting regressive assimilation in [+nasal] at some point in the early history of Proto-Bantu.

Returning to those languages in which nasal consonant harmony is manifested in alternations, note that all the well known cases cited above (Kongo, Yaka, Lamba, etc.) involve nasalization rather than denasalization. In other words, an input /d/ (or /l/, or /r/) surfaces as [n] due to harmony, but an input /n/ (e.g. in reciprocal /-an-/) does not harmonize with a preceding (voiced) oral consonant by denasalizing to [d], [l] or [r]. In this respect, Bantu nasal consonant harmony has the characteristics of a 'dominant-recessive' system, with [+nasal] (or privative [nasal]) as the dominant or 'active' feature value.

An interesting case where Bantu nasal consonant harmony can have the effect of either nasalization or denasalization ('oralization'), depending on circumstances, is **Tiene** (Kitiene; Ellington 1977, Hyman & Inkelas 1997, Hyman 2006), where nasal consonant harmony plays part in an unusual stem-template system. In Tiene verbs, the so-called DStem (Derivational Stem, i.e. root + derivational suffix) must be exactly bimoraic: either CV:C or CVCVC. Further restrictions apply to DStems of the CVCVC variety: C_2 must be coronal, C_3 must be non-coronal (labial or velar), and C_2 and C_3 are required to agree in nasality, such that if one of them is [+nasal], the other must be [+nasal] as well.

Because of the place of articulation sequencing restrictions (C_2 = coronal, $C_3 \neq$ coronal), the addition of derivational affixes to CV(:)C roots results in a remarkable interplay between infixation and suffixation, conditioned by the place of articulation of the root-final consonant as well as that of the affix consonant (Hyman & Inkelas 1997, Hyman 2006). Suffice it to say that (coronal) C_2 may belong either to the verb root or to an infix, whereas (non-coronal) C_3 may belong either to a suffix or to the verb root. What is of importance here, however, is merely the nasal agreement restriction on C_2 and C_3. The harmony effects are illustrated by the forms in (37); the CVCVC stem is enclosed in curly brackets, all affixal material within the template is underlined. In each case, the affix itself consists of a single consonant; the additional vowel (V_2) results from the bimoraic template requirement, and its quality is predictable from context (Hyman & Inkelas 1997).

(37) Tiene: nasal agreement in C_2 and C_3 of CVCVC template (Hyman 2006)

<table>
<tr><td>a.</td><td colspan="4">Nasalization in infixed applicative /-lV-/</td></tr>
<tr><td></td><td>bák-a</td><td>‘reach’</td><td>{bá-<u>la</u>-k}-a</td><td>‘reach for’</td></tr>
<tr><td></td><td>jɔb-ɔ</td><td>‘bathe’</td><td>{jɔ-<u>lɔ</u>-b}-ɔ</td><td>‘bathe for’</td></tr>
<tr><td></td><td>dum-a</td><td>‘run fast’</td><td>{du-<u>ne</u>-m}-ɛ</td><td>‘run fast for’</td></tr>
<tr><td></td><td>lɔŋ-ɔ</td><td>‘load’</td><td>{lɔ-<u>nɔ</u>-ŋ}-ɔ</td><td>‘load for’</td></tr>
<tr><td>a.</td><td colspan="4">Nasalization in suffixed stative /-Vk-/</td></tr>
<tr><td></td><td>jaat-a</td><td>‘split’</td><td>{jat-<u>ak</u>}-a</td><td>‘be split’</td></tr>
<tr><td></td><td>ból-a</td><td>‘break’</td><td>{ból-<u>ek</u>}-ɛ</td><td>‘be broken’</td></tr>
<tr><td></td><td>vwuɲ-a</td><td>‘mix’</td><td>{vwuɲ-<u>eŋ</u>}-ɛ</td><td>‘be mixed’</td></tr>
<tr><td></td><td>sɔ́n-ɔ</td><td>‘write’</td><td>{sɔ́n-<u>ɔŋ</u>}-ɔ</td><td>‘be written’</td></tr>
</table>

Note that the harmony effects in (37) are bidirectional—regressive assimilation in (37a), progressive assimilation in (37b)—and in both cases, an oral consonant is assimilating to a nearby nasal (cf. the asymmetry in Yaka, Lamba, etc., discussed above). Since none of the relevant derivational suffixes happens to contain an underlying nasal, it is the suffix consonant that assimilates to a root consonant in both scenarios in (37), rather than vice versa.

However, when the oral consonant is one that cannot undergo nasalization, namely the fricative /s/, the nasal yields instead, by denasalizing to a (voiced) oral stop. This happens when causative /-s-/ is infixed into a nasal-final root, as shown in (38b). Note that under these circumstances, we are seeing a root consonant harmonizing with an affix consonant. (See §4.3.3 for discussion of the formal-analytical implications of the directionality and denasalization aspects of the Tiene harmony.)

(38) Tiene: denasalization with infixed causative /-sV-/ (Hyman 2006):

<table>
<tr><td>a.</td><td>lab-a</td><td>‘walk’</td><td>{la-<u>sa</u>-b}-a</td><td>‘cause to walk’</td></tr>
<tr><td></td><td>kuk-a</td><td>‘be sufficient’</td><td>{ku-<u>si</u>-k}-ɛ</td><td>‘make sufficient’</td></tr>
<tr><td>b.</td><td>tóm-a</td><td>‘send’</td><td>{tó-<u>se</u>-b}-ɛ</td><td>‘cause to send’</td></tr>
<tr><td></td><td>dím-a</td><td>‘get extinguished’</td><td>{dí-<u>se</u>-b}-ɛ</td><td>‘extinguish’</td></tr>
<tr><td></td><td>suɔm-ɔ</td><td>‘borrow’</td><td>{sɔ-<u>sɔ</u>-b]-ɔ</td><td>‘lend’</td></tr>
</table>

Recall from (37) that Tiene nasal consonant harmony triggers nasalization not only of /l/, as in most other languages, but also of the (redundantly) voiceless velar stop /k/. Though this is somewhat unusual, it is not unheard of elsewhere in Bantu, in particular in the northwestern part of the Bantu area. For example, Greenberg (1951) states that in various languages and dialects of the Teke subgroup (to which Tiene has sometimes been claimed to belong), the stative suffix /-Vɡ/ harmonizes with a root-final nasal, surfacing as [-Vŋ] (see below for more details on Teke). Greenberg further claims that the same also happens in **Basaa** with respect to 'continuative and imperative' formation in /-k/, stating that the relevant suffixes harmonize to [-ŋ] when the last preceding consonant is a nasal (imperative [lob-ok] from /lob-/ 'bite', but [tam-aŋ] from /tam-/ 'wish', [han-aŋ] from /han-/ 'choose'); however, I have been unable to confirm this observation in other descriptive sources on Basaa. Finally, note that the abovementioned regressive nasal consonant harmony in Pangwa (Stirnimann 1983), which is triggered by reciprocal /-an-/, converts velar /x/ to [ŋ] ([anuŋ-an-] 'receive from each other' from /anux-/ 'receive').[50]

As discussed in detail by Hyman (2006), templatic restrictions very similar to those of Tiene are found in languages of the Teke subgroup. In $C_1VC_2VC_3V$ verb stems in **Kukuya** (Paulian 1975, Hyman 1987), the highly impoverished inventory for C_2 position consists of the coronals /t, l, n/ and that for C_3 of the non-coronals /p, k, m/.[51] However, C_2 and C_3 must either both be nasal (/C…n…m/) or both oral (/C…l…p/, /C…l…k/ /C…t…p/, /C…t…k/), just as in Tiene. In the Teke variety that Hyman (2006) refers to as **Teke-Gabon**, the C_2 position in $C_1VC_2VC_3V$ verbs can be occupied by coronal /l, r, n/ or labial /b, m/, whereas C_3 must be dorsal /ɡ, ŋ/ (Hyman 2006, based on Hombert 1993). Many of the CVCVCV stems in question no doubt incorporate a frozen reflex of the abovementioned stative suffix /-Vɡ/ discussed by Greenberg (1951). In Teke-Gabon, just as in Tiene and Kukuya, C_2 and C_3 must either both be nasal (/C…n…ŋ/, (/C…m…ŋ/) or both oral (/C…l…ɡ/, /C…r…ɡ/ /C…b…ɡ/).

Another case that resembles the ones just mentioned is **Izere** (Afuzare, Zarek) a Nigerian language belonging to the Plateau subgroup of the Niger-Congo family (Blench & Kaze 2000, Blench 2001, Hyman 2006). Here, too, the C_2–C_3 combinations that are possible in $C_1VC_2VC_3$ stems are highly restricted, and a nasal agreement restriction seems to operate over these two positions. However, unlike in Tiene, Kukuya and Teke-Gabon, the Izere cooccurrence restriction is *directional*: if C_2 is nasal, then C_3 must likewise be nasal (/C…n…ŋ/, /C…m…ŋ/), but C_3 can be nasal without C_2 necessarily being nasal (e.g. /C…r…ŋ/, /C…s…m/). Izere nasal consonant harmony almost certainly produced [k] ~ [ŋ] alternations at an earlier historical stage. There is reason to believe that Izere once had a singular suffix /-k/ (Wolff & Meyer-Bahlburg 1979, Gerhardt 1984; see Hyman 2006), as suggested by singular-pluractional pairs like /tsíb<u>ík</u>/ vs. /tsip/ 'twist', and also /fúb<u>úk</u>/ vs. /fú<u>sù</u>p/

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[50] Recall also the case of UMbundu (Schadeberg 1982; see n. 46 above), in which nasalization targets both /l/ (→ [l̃]) and /k/ (→ [h̃]).

[51] The phonemic transcriptions are somewhat misleading here, in that /p, t, k/ have lenited realizations outside of C_1: [b ~ β], [r], [k ~ ɡ ~ ɣ]. For this reason, a more representative statement of the C_2 and C_3 inventories might perhaps be {n, l, r} and {b, ɡ, m}, respectively. In addition to the C_2–C_3 combinations mentioned above, verb stems may also take the shape /C…k…p/, with a dorsal C_2 followed by a labial C_3.

'sip', /kɔ́bɔ́k/ vs. /kɔ́sɔ́p/ 'loan, borrow', the latter two with an infix /-s-/ in the pluractional form. When C_2 is nasal, we find /-ŋ/ instead in the singular member of such pairs: /tɛ́mɛ́ŋ/ vs. /tɛ́m/ 'cut, chop down', /tɔ́mɔ́ŋ/ vs. /túsɔ́m/ 'push'.

Voicing specifications are often seen to interact with nasal consonant harmony. For example, in the 'canonical' variety of Bantu nasal consonant harmony—as represented by Lamba, Yaka, etc. (as opposed to Tiene, Kukuya or Teke-Gabon)—harmony specifically targets *voiced* oral consonants, usually liquids and/or stops. The same is true of the root-level co-occurrence restrictions in Ganda described earlier.[52] A root-internal nasal consonant harmony which specifically targets liquids is found in the Chadic language **Hausa**. According to Newman (2000:410), /l/ and /n/ cannot co-occur root-internally 'in normal CVCV sequences' within roots. As for the root-internal co-occurrence of /n/ and /ɽ/ (a retroflex flap), the restriction is directional: whereas /ɽ…n/ is well attested, */n…ɽ/ is not allowed in Hausa roots.[53]

In 'canonical' Bantu nasal consonant harmony, as well as its less typical Tiene counterpart, the harmony is manifested overtly through alternations in the surface shape of morphemes (primarily affixes). Other cases where consonants are seen to assimilate in nasality across an intervening (oral) vowel, resulting in overt alternations, are found in the Australian language **Nyangumarta** (Nyangumarda; Hoard & O'Grady 1976) as well as in **Ulithian**, a Micronesian language (Sohn & Bender 1973: 59).

One of the highly unusual aspects of nasal consonant harmony in Tiene was the fact that it is partly achieved by means of denasalization, as we saw in (38) above. Though this is a rare occurrence, it is not unheard of elsewhere. For example, denasalization as a manifestation of long-distance assimilation seems to occur in the Austronesian language **Sawai** (Whistler 1992). Here the /n/ of the possessive classifiers /nɔ-/ (edibles) and /ni-/ (non-edibles) turns into /r/ (= [ɾ]) before a pronominal suffix that itself contains /r/: /nɔ-ri/ → [ɾɔ-ɾi] 'their edible X' and /nɔ-ɾ/ → [ɾɔ-ɾ] 'our (incl.) edible X'.

In all of the languages that have been mentioned so far in this section, the nasal consonant harmony in question concerns the co-occurrence of a fully nasal consonant with a fully oral one. This prompts the question whether consonant harmony ever regulates the co-occurrence of a nasal *contour segment*—that is, a prenasalized obstruents—with either a fully nasal or a fully oral consonant of some kind. Such harmony requirements do exist. For example, in Ganda, roots are subject to an additional restriction that prohibits the co-occurrence of full nasals and voiced prenasalized stops (Katamba & Hyman 1991). Roots with the shape NVN are allowed in Ganda, but *NVND and *NDVN are banned (an independent constraint rules out *NDVND as well). Note that this harmony is not place-dependent, unlike the one

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[52] According to Katamba & Hyman (1991), Ganda also has a place-dependent co-occurrence restriction on nasals and *voiceless* stops, though this is asymmetric: homorganic *NVT sequences are banned, while homorganic TVN is allowed.

[53] Newman (2000) describes the apical /r/ (realized either as a trill [r] or tap [ɾ]) as a more recent addition to the Hausa inventory, the retroflex flap /ɽ/ being 'the native Hausa R'. Apical /r/ does not seem to be subject to any of the co-occurrence restrictions that apply to /ɽ/.

governing the co-occurrence of N and D, as discussed above: it applies to non-homorganic consonant pairs as well as homorganic ones. It should also be emphasized that it is only prenasalized *voiced stops* that are barred from co-occurring with a full nasal in Ganda. Combinations such as NVNT, NVNS, NVNZ are allowed (where T = voiceless stop, S = voiceless fricative, Z = voiced fricative).

Another well known case of consonant harmony involving nasal contour segments is that of the Adamawa-Ubangi language **Ngbaka** (Thomas 1963, Mester 1988b, Sagey 1990, Walker 2000b, 2000c). In Ngbaka roots, a prenasalized (voiced) obstruent is not allowed to co-occur with a homorganic full nasal, nor with a homorganic oral (voiced) obstruent, as illustrated in (39). In addition, homorganic voiced and voiceless (oral) obstruents do not co-occur either (e.g. */p…b/; see the discussion of laryngeal harmony in §2.4.7 below). Note that unlike in Bantu nasal consonant harmony, the co-occurrence of a full nasal with a voiced oral consonant is permitted in Ngbaka (e.g. /boma/ 'how'). The overall system of co-occurrence restrictions is best understood in terms of a scale of relative similarity: T – D – ND – N (see Mester 1988b, Walker 2000b). Homorganic consonants drawn from adjacent positions on this scale do not co-occur within roots.

(39) Ngbaka: Place-dependent nasal consonant harmony in roots (Walker 2000c)

a. Well-formed roots with homorganic voiced consonants

nɑnɛ̀	'today'
$^{ŋ͡m}$g͡ba$^{ŋ͡m}$g͡bɔ̀	'species of caterpillar'
bàbā̄	'companion'

b. Disallowed root-internal sequences (in either order)

*m…^{m}b	*n…^{n}d, *n…^{n}z	*ŋ…^{ŋ}g	*ŋ͡m…$^{ŋ͡m}$g͡b
*^{m}b…b	*^{n}d…d, *^{n}z…z	*^{ŋ}g…g	*$^{ŋ͡m}$g͡b…g͡b

c. No restriction on heterorganic pairs

mà^{ŋ}gà	'net'
bá^{ŋ}gá	'jaw'

As the (39c) examples show, the harmony requirement in Ngbaka is parasitic on prior agreement in place of articulation. The confinement of harmony to homorganic consonant pairs mirrors that of some of the Ganda co-occurrence restrictions discussed above.

Another potential case of harmony involving prenasalized vs. oral stops, albeit a rather more tentative one, is found in the Oceanic language **Yabem** (Dempwolff 1939, Bradshaw 1979, Ross 1993, 1995). In Yabem, irrealis mood is marked by featural affixation: in irrealis forms, a 'floating' [+nasal] feature docks onto any and all prenasalizable consonants in the verb root. Etymologically this prenasalization goes back to a prefix morpheme **n-* (< **na-*), which coalesced with a root-initial obstruent (Bradshaw 1979:203). The class of consonants that count as prenasalizable in Yabem, such that they can host the floating [+nasal] feature, consists of all voiced obstruents, in addition to /s/ in low-toned contexts.[54] The irrealis prenasalization pattern is illustrated in (40). The roots in (40a) contain no prenasalizable consonant, and the [+nasal] feature fails to surface. In (40b) a root-initial obstruent is targeted, and in (40c) the target is root-internal. In (40d) the root contains two prenasalizable consonants, and the floating feature surfaces on both.[55]

(40) Yabem: ‘floating’ prenasalization in irrealis forms (Ross 1993)

	Realis	*Irrealis*	
a.	ká-létí	já-létí	‘I run’
	ká-kátɔ́ŋ	já-kátɔ́ŋ	‘I make a heap’
b.	ká-dàm^{w}è	já-^{n}dàm^{w}è	‘I lick’
	ká-sàìʔ	já-^{n}sàìʔ	‘I pull off, snap’
c.	ká-màdòm	já-mà^{n}dòm	‘I break in two’
	ká-lèsù	já-le^{n}sù	‘I poke, stir’
d.	ká-dàbìŋ	já-^{n}dà^{m}bìŋ	‘I approach’
	ká-gàb^{w}àʔ	já-^{ŋ}gà^{m}b^{w}àʔ	‘I untie’

Where Yabem irrealis prenasalization is of potential relevance in the present context is in cases of *multiple* prenasalization, as in (40d). This might conceivably be due to a root-level nasal consonant harmony restriction against the combination *ND…D (and *N…ND), whereas ND…ND and D…D sequences are allowed. From this perspective, irrealis prenasalization in Yabem is analogous to the cases of morphological palatalization in Harari (see §2.4.1.2) and in certain Chadic languages (§2.4.1.1). As potential instances of consonant harmony, all of these cases are far from conclusive. Their interpretation reduces to a more

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54 Historically, /s/ in low-toned syllables goes back to a voiced */z/ at an earlier stage, and thus prenasalized [^{n}s] in irrealis forms likewise goes back to earlier *[^{n}z] (Ross 1995). See §3.3.2 and Hansson (2004b) for detailed discussion of tone-voicing interaction in Yabem.

55 Ross (1993:140) gives these forms with /ká-/ as the 1Sg prefix in irrealis and realis alike, rather than /ká-/ in realis and /já-/ in irrealis forms (the same list reappears in Ross 1995:711). This is almost certainly a mistake, which I have here attempted to correct: the realis/irrealis distinction is signaled by complementary sets of person-number prefixes in the singular (though not in the plural), with the realis forms using 1Sg /ka-/, 2Sg /ko-/, 3Sg /ke-/, and the irrealis ones 1Sg /ja-/, 2Sg /o-/, 3Sg /e-/. According to Dempwolff (1939), this allomorphy holds for disyllabic and monosyllabic roots alike. Though Dempwolff happens not to cite any 1Sg irrealis forms of disyllabic verbs, he shows irrealis forms with 2Sg /o-/ and 3Sg /e-/. Note also that elsewhere Ross (1993:135) cites the 3Sg irrealis form [é-tólɔ́ŋ] ‘he will carry’, with /e-/ as distinct from its realis counterpart /ke-/. In any case, the phonological shape of the subject-agreement prefix is not of direct relevance here.

general question: what is the appropriate analysis for multiple docking in featural affixation? This question is left to future research.

2.4.5. Liquid Harmony

The class of consonant harmony phenomena covered in this section comprises all assimilatory interactions among liquids, as well as between liquids and non-liquids (with the exception of [l] ~ [n] or [r] ~ [n] alternations, which were counted under nasal consonant harmony in §2.4.4 above). While liquid harmony seems to be comparatively rare in the world's languages, it is nevertheless solidly attested, both as a root-internal co-occurrence restriction and as an active process generating alternations in morphologically complex forms.

As a natural class, the 'liquid' category contains two main types of segments: laterals and rhotics. In most representational frameworks these are distinguished by a feature [±lateral]. A handful of cases exist where liquid harmony targets precisely the lateral vs. rhotic distinction, thus prohibiting the co-occurrence of [l] and [r] within some domain. At least three cases of [l] ~ [r] alternations due to liquid harmony are attested. One of these is the Bantu language **Bukusu** (Lubukusu; de Blois 1975, Odden 1994) where a suffixal /l/ is realized as [r] when preceded by an [r] somewhere in the stem. This is illustrated in (41), where the applicative suffix /-il-/ is seen surfacing as [-il-] or [-ir-] depending on liquid harmony with the root-final consonant (or [-el-], [-er-] by vowel height harmony). Unless stated otherwise, all Bukusu forms are cited from the electronic files on Bukusu contained in the *Comparative Bantu On-Line Dictionary (CBOLD)* lexicographic database (http://linguistics.berkeley.edu/CBOLD).

(41) Bukusu: alternations due to transvocalic liquid harmony (applicative /-il-/)

a.	xam-il-a	'milk for'
	but-il-a	'pick/gather for'
	te:x-el-a	'cook for'
	i:l-il-a	'send thing' (Odden 1994)
b.	bir-ir-a	'pass for'
	ir-ir-a	'die for'
	kar-ir-a	'twist' (Odden 1994)

The forms in (41a) clearly establish that the underlying form of the suffix is /-il-/. After an /r/-final root, the suffix surfaces as [-ir-] (41b); the suffixal liquid is thus required to agree in [±lateral] with a preceding liquid. In the cases in (41b), the trigger and target are separated only by a vowel, but in fact the harmony also holds at greater distances, as (42) illustrates. Odden (1994) describes the assimilation as applying 'across unbounded strings', and thus presents only harmonized forms with [-ir-] after roots with initial /r/ (e.g. [rum-ir-a] 'send someone'). According to the CBOLD files, on the other hand, the long-range version of liquid harmony appears to be optional in Bukusu.

(42) Bukusu: long-distance liquid harmony (optional?)

a.	ruk-ir-a ~ ruk-il-a	'plait for'
	rum-ir-a ~ rum-il-a	'send for'
b.	reːb-er-a	'ask for' (Odden 1994)
	resj-er-a	'retrieve for' (Odden 1994)

It thus seems that transvocalic and unbounded liquid harmony are both found in Bukusu, the former obligatory, the latter (perhaps) optional. This is directly parallel to the situation with sibilant harmony in Rwanda (see §2.4.1.1 above), which is obligatory in transvocalic contexts but optional at greater distances. It is also somewhat analogous to nasal consonant harmony in Bantu languages (§2.4.4), and sibilant harmony in Omotic languages (§2.4.1.1), where transvocalic and unbounded versions of the same harmony coexist in different but closely related languages.

Bukusu liquid harmony can also be observed as a root-internal co-occurrence restriction, though a great deal of [r] ~ [l] variability renders the picture somewhat unclear, at least from a synchronic perspective. One source of evidence for root-internal liquid harmony is loanword adaptation (e.g. /eː-loli/ ~ /eː-roːri/ 'truck' < Eng. *lorry*). The examples in (43) illustrate the diachronic manifestation of liquid harmony in roots. Bukusu /l/ and /r/ are the regular reflexes of Proto-Bantu **d* and **t*, respectively, but Proto-Bantu **d* may surface as /r/ by virtue of harmonizing with an /r/ (< **t*) in the same morpheme. The doublet forms in (43a) indicate optionality and/or variability (either inter- or intradialectal) in the application of harmony.[56]

(43) Bukusu: root-internal liquid harmony (with Proto-Bantu sources)

a.	-rare	'iron/copper ore'	(< **tade*)
	-reːr-a ~ -leːr-a	'bring'	(< **deet-a*)
	-roːr-a ~ -loːr-a	'dream (v)'	(< **doot-a*)
b.	-lilo-	'fire'	(< **dido*)
	-lol-a	'look at'	(< **dod-a*)
	-lul-a	'be bitter'	(< **dud-a*)

The diachronic correspondences in (43a) seem to suggest an asymmetry in the application of harmony, whereby /l/ assimilates to a nearby /r/, but not vice versa. Diachronically, liquid harmony appears to produce /r…r/ regardless of whether the original sequence was /r…l/ or /l…r/. This suggests that [–lateral] /r/ is 'dominant', in some sense. Synchronically, /l…l/

[56] It appears that the [r] ~ [l] variation in Bukusu can sometimes give rise to reflexes that are the exact opposite of what is expected from **d* > /l/ and **t* > /r/; for example, the CBOLD listings include an alternative form /-roːl-/ for 'dream'.

sequences exist as well, but these are virtually always reflexes of Proto-Bantu **d...d*; in other words [l…l] is never the result of liquid harmony.[57]

Furthermore, although the examples in (43a) suggest that liquid harmony applies bidirectionally within roots, there are some indications that the tendency for anticipatory harmony (/l…r/ → [r…r]) may be stronger than that for perseveratory harmony (/r…l/ → [r…r]). A search for disharmonic sequences in the CBOLD database yielded only 5 examples of […lV(:)r…], whereas 28 examples of […rV(:)l…] turned. Although these results are merely suggestive, it should be noted that in some of the […rV(:)l…] cases, the /l/ is suffixal. A greater dispreference for [l…r] than [r…l] may perhaps also lie behind the fact that English *lorry* gets harmonized when borrowed (/-roːri/ ~ /-loli/ 'truck'), whereas Swahili *-rodi* (~ *-lodi*; itself a borrowing from English *lord*) does not undergo harmony when borrowed into Bukusu (/-roli/ 'fighter, a person who enjoys fighting').

Whereas liquid harmony in Bukusu results in the 'delateralization' (or 'rhotacization') of an underlying /l/, the exact opposite is seen in **Atsugewi**, a Palaihnihan language of California (Good 2004, based on Talmy 1972). Here we see /r…l/ sequences systematically harmonizing to [l…l], not only across an intervening vowel (/s-'-w-**r**a-**l**uts-a/ → [sw̓**l**a**l**ːúts^h] 'I scraped the fur off the hide') but also at greater distances (/'-w-p-**r**u-swa**l**-ik's-a / → [p'**l**uswa**l**ík'sa] 'his penis stayed limp [on him]; he couldn't get an erection'). Good (2004) cites Talmy as stating (in unpublished notes on Atsugewi phonology) that /r/ also harmonizes with a following /n/, presumably resulting in /r…n/ → [n…n] (which would here have been counted under nasal consonant harmony; §2.4.4), but was unable to identify any cases of this in the data cited in Talmy (1972).

Another case where /r/ assimilates to a nearby /l/ is found in the Malayo-Polynesian language **Sundanese** (Robins 1959, Cohn 1992, Holton 1995, Suzuki 1998, 1999, Curtin 2001). In Sundanese, the plural/distributive marker /-ar-/, like many other affixes with -VC- shape, is infixed after a root-initial onset consonant, as shown in (44a–b). When that C_1 is /l/, however, the /r/ of the /-ar-/ infix assimilates to it, surfacing instead as [-al-] (44c). Infixed material is indicated by underlining in all the forms cited.

(44) Sundanese: liquid alternations in plural/distributive infix /-ar-/ (Cohn 1992)

	Singular	*Plural*	
a.	kusut	k-<u>ar</u>-usut	'messy'
	poho	p-<u>ar</u>-oho	'forget'
	di-visualisasi-kɨn	di-v-<u>ar</u>-isualisasi-kɨn	'visualized'

[57] Counterexamples are rare; one such case is 'bring' which has /-leːl-a/ as a third alternative to the /-reːr-a/ ~ /-leːr-a/ shapes listed in (43a). Note, finally, that for entirely independent reasons, Proto-Bantu **t…t* never results in Bukusu /r…r/. Instead, due to the dissimilatory sound change known as Dahl's Law, such sequences instead end up as Bukusu /t…r/: **t…t* > **d…t* (after the change of Proto-Bantu **d* to /l/), followed by **t* > /r/ and **d* > /t/.

b.	rɨwat	r-ar-ɨwat	'startled'
	rahɨt	r-ar-ahɨt	'wounded'
c.	lɨtik	l-al-ɨtik	'little'
	ləga	l-al-əga	'wide'

As an illustration of the [-ar-] ~ [-al-] alternation, (44) is an oversimplification; the full range of facts is much more intricate. Most importantly, the liquid harmony that is in effect in (44c)—as well as in (44b), though less obviously so—interacts in complex ways with a general *dissimilatory* ban against [r…r] sequences (Cohn 1992, Holton 1995, Suzuki 1998, 1999, Curtin 2001). For example, the plural of [pər.ce.ka] 'handsome' is [p-a.l-ər.ce.ka], with dissimilation /r…r/ → [l…r], whereas that of [cu.ri.ga] 'suspicious' is [c-a.r-u.ri.ga] (not *[c-a.l-u.ri.ga]), due to liquid harmony between adjacent-syllable onsets overriding the expected dissimilation. Sundanese liquid harmony and its implications, especially as regards directionality effects, is discussed in detail in §4.3.3 below. Here it will suffice to point out that Sundanese liquid harmony, like that of Atsugewi, has the effect of 'lateralizing' an affixal /r/ (44c), whereas harmony in Bukusu results in the 'rhotacization' of an affixal /l/. Note also that although superficially the directionality of harmony would seem to be anticipatory (left-to-right) in Atsugewi and perseveratory (left-to-right) in Bukusu and Sundanese, in all three cases it is an affix consonant that is assimilating to a consonant in the base of affixation. The general issue of directionality patterns in consonant harmony (including 'stem control') is taken up in §3.1 below.

There are also attested cases where liquid harmony is manifested solely as a root-internal co-occurrence restriction, that is, as a prohibition on tautomorphemic [l…r] or [r…l] sequences. In **Pohnpeian** (Pohnpeian), for example, the alveolar trill /r/ and the dental lateral /l/ make up one of the segment pairs that 'are almost never found within the same morpheme' (Rehg & Sohl 1981:46). Roots with /r…r/ or /l…l/ combinations are relatively numerous, as in (45a–b), whereas roots with disharmonic /r…l/ or /l…r/ sequences, as in (45c), are extremely rare at best. (It is quite possible that the examples in (45c) are either polymorphemic or loanwords of fairly recent origin.)

(45) Pohnpeian: root-internal liquid harmony (Rehg & Sohl 1981)

a. Harmonic roots with /r…r/:

raːr	'finger coral'
rere	'skin, peel (v)'
rer	'tremble'

b. Harmonic roots with /l…l/:

lel	'be wounded'
lul	'flame (v)'
lɔl	'deep'

c. Disharmonic roots (/l…r/, /r…l/) hardly attested:
rijaːla 'be cursed'
lirop 'mat'

As noted in §2.4.3 above, Pohnpeian /r/ is phonetically velarized, [rˠ], and [l]–[rˠ] is merely one of several pairings of highly similar consonants differing in velarization that are either strongly disfavored or categorically banned within the Pohnpeian lexicon (e.g. [t]–[t̪s̪ˠ] or [m]–[mˠ]). It is therefore far from certain whether the pattern in (45) should be categorized as being an instance of 'liquid harmony' in the same sense as the Bukusu or Atsugewi harmony processes. It is nevertheless true that morpheme-internal co-occurrence restrictions on /l/ and /r/—both assimilatory ones (harmony) and dissimilatory ones—are quite common in Austronesian languages, such as in **Javanese** (Uhlenbeck 1949, 1950, Mester 1988b, Yip 1989) and of course Sundanese (Cohn 1992) as described above. In Javanese, the disharmonic sequence /l…r/ is permitted (and many morphemes with original /r…r/ have historically been dissimilated to /l…r/), whereas the reverse sequence, /r…l/, is prohibited.[58] As an additional complication, harmonic liquid sequences /l…l/, /r…r/ are only allowed as the C_1–C_2 pair in $C_1VC_2VC_3$ roots. Many of these can presumably be explained as being due to initial CV-reduplication (if not synchronically, then at least historically; cf. Cohn 1992 on the same problem regarding /r…r/ sequences in closely related Sundanese).

Outside of Austronesian, root-internal liquid harmony is also attested in **Hausa**, where /l/ and the retroflex flap /ɽ/ cannot co-occur 'in normal CVCV sequences' within the root (Newman 2000:410). The same is true of /l/ vs. /n/, as was briefly mentioned in §2.4.4 above.[59] On the other hand, Hausa places no such restrictions on the co-occurrence of /l/ and the other rhotic phoneme, the apical /r/ (realized as a trill [r] or a tap [ɾ]). As Newman (2000) points out, apical /r/ is a comparatively recent addition to the Hausa consonant inventory.

All the cases examined so far have been examples of what might be called 'inter-liquid' harmony: long-distance assimilation between liquid segments of different kinds (laterals vs. rhotics). There also exists a different type of liquid harmony, in which liquids and (oral) non-liquid consonants harmonize with each other. If a feature like [±liquid] is what singles out laterals and rhotics as a natural class (see Walsh Dickey 1997 for a proposal along these lines), then liquid harmony of this latter type could be interpreted as agreement in terms of [+liquid]. However, as both of the attested cases involve the glide /j/ vs. the liquids /r, l/, the harmony might perhaps be defined as involving the feature [±consonantal] (see §2.5 for discussion).

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[58] Counterexamples exist, but these are typically dialect borrowings or loans from Arabic, Dutch, Portuguese, and other non-Austronesian languages (Uhlenbeck 1949, Mester 1988b).
[59] The combined prohibition of /l/–/ɽ/ and /l/–/n/ co-occurrences makes Hausa an interesting near-parallel to Atsugewi, where /r/ (allegedly) harmonizes both with /l/ and with /n/, as mentioned earlier.

In the Bantu language **Basaa**, the applicative suffix allomorph /-Vl/, which attaches to monosyllabic CVC roots, surfaces instead as [-Vj] after roots with the shape /CVj/. This is illustrated in (46a–b). Interestingly, in /jV/ roots, harmony is not triggered by the root-initial glide (46c). Furthermore, harmony shows no sign of holding true morpheme-internally, as evidenced by roots with the shape /jVl/ (46d). The harmony (or 'transvocalic assimilation', at any rate) is thus solely triggered by a root-final /j/, and targets only the /l/ of an immediately following applicative suffix.

(46) Basaa: liquid harmony in applicative /-Vl/ (Lemb & de Gastines 1973)

a.	tìŋ-ìl	'tie for/with'	(root = /tèŋ-/)
	ɓém-êl	'wait with/for'	(root = /ɓám-/)
	ɓòl-òl	'go bad for/because of'	(root = /ɓɔ̀l-/)
b.	tój-ôj	'drip for'	(root = /tɔ́j-/)
	ɓèj-èj	'shine on/for'	(root = /ɓàj-/)
	ɲój-ôj	'disappear for'	(root = /ɲɔ́j-/)
c.	jê-l	'appear to/for'	(root = /jɛ́-/)
	jò-l	'steal wine at'	(root = /jɔ̀-/)
d.	jìla	'become, transform'	
	jɛ́li	'be revealed'	

In terms of the properties of the segments involved, the Basaa [l] ~ [j] alternation involves not merely [±liquid] (or its equivalent) but also [±lateral]. Basaa lacks rhotics, which invites the possibility of analyzing the /l/–/j/ interaction as being due to [±lateral] harmony, just as in Bukusu, Atsugewi and Sundanese. However, harmony-like interactions between glides and liquids are attested in at least one other language, where such a reinterpretation is not an option. This is the Bantu language **Pare** (Kipare, Asu; Odden 1994), where a suffixal /j/ optionally harmonizes with a root-final /l/ or /r/. The harmony alternations are exhibited by the applicative suffix /-ij-/ (47a–b) as well as by perfective /-ije/ (48a–b). As the forms in (47c) and (48c) show, the assimilation is strictly transvocalic.

(47) Pare: liquid harmony in applicative suffix /-ij-/ (Odden 1994)

a.	-tet-ij-a	'say for'	
	-big-ij-a	'beat for'	
b.	-tal-il-a ~ -tal-ij-a	'count for'	
	-zor-ir-a ~ -zor-ij-a	'buy for'	
c.	-rumb-ij-a	'make pots'	(not *[-rumb-ir-a])

(48) Pare: liquid harmony in perfective suffix /-ije/ (Odden 1994)

a. -kund-ije ‘liked (perf.)’
-dik-ije ‘cooked (perf.)’
-von-ije ‘saw (perf.)’

b. -tal-ile ~ -tal-ije ‘washed (perf.)’
-zor-ire ~ -zor-ije ‘healed (perf.)’

c. -roŋg-ije ‘made (perf.)’ (not *[-roŋg-ire])

In addition, the /j/ of these two suffixes in Pare is subject to an alternation which appears, at least superficially, to qualify as stricture harmony: [j] ~ [ɟ]. This alternation, as well as similar phenomena in other Bantu languages, will be discussed in more detail in §2.4.6 below.

The Pare alternations, unlike those of Basaa, cannot be understood as involving agreement in [±lateral] alone, since /j/ is assimilating to /r/ and /l/ alike. Instead, the harmony must be based on whatever feature underlies the glide vs. liquid distinction, such as [±liquid] (if such a feature is adopted) or [±consonantal]. It is clear, however, that harmony in terms of [±lateral] is also involved, since the glide surfaces as [r] after [r] but as [l] after [l]. Liquid harmony in Pare can thus be said to combine ‘inter-liquid’ (lateral vs. rhotic) harmony with liquid vs. non-liquid harmony.

One other potential case of liquid harmony deserves mention, though its interpretation as involving consonant harmony is far from conclusive. This is the curious lateral alternation that is found in the Bantu language **Mwiini** (Chimwiini; Kisseberth & Abasheikh 1975). Mwiini has two kinds of alveolar laterals, which are represented as ‘l’ and ‘ƚ’ by Kisseberth & Abasheikh (1975). Judging from their phonetic description, the latter appears to be a lateral tap.[60] In what follows, I will transcribe the tap ‘ƚ’ as /ɺ/, which contrasts with the ‘full’ lateral /l/ (on the existence of lateral taps in other languages, see Ladefoged & Maddieson 1996.)

The relevant facts concern the realization of the perfective suffix, which has a bipartite structure, /-iːɺ-e/. The suffix is seen to surface unaltered (modulo the effects of vowel height harmony) in the forms in (49a). When the preceding root ends in a non-tap liquid—namely /l/ or /r/—the lateral tap of the suffix changes to its non-tap counterpart, [l] (49b). Furthermore, when the root ends in a tap, the tap of the suffix dissimilates from it, by again surfacing as the non-tap [l] (49c).[61] According to Kisseberth & Abasheikh (1975), the same alternations are

[60] Kisseberth & Abasheikh (1975:250–251) describe the articulatory difference between Mwiini ‘ƚ’ and ‘l’ as follows: ‘Preliminary instrumental investigation suggests that in the articulation of *ƚ*, the tip of the tongue strikes lightly against a small area to the front of the alveolar ridge without any lateral contact. The area of contact in the case of *l*, on the other hand, is larger, and there is lateral contact. The duration of *l* is longer than the duration of *ƚ*.’

[61] In most /ɺ/-final roots, the /ɺ/ changes to [z] before the perfective suffix (by a so-called ‘consonant mutation’ process). Therefore, the only cases in which the dissimilation in (49c) can be observed are those roots that are lexical exceptions to mutation. According to Kisse-

also observed in the applicative suffix /-iɺ-/, the only other Mwiini suffix that contains /ɺ/, but they do not provide data to illustrate this.

(49) Mwiini: alternations in perfective suffix /-iːɺ-e/ (Kisseberth & Abasheikh 1975)

a. kun-iːɺ-e ‘he scratched’
som-eːɺ-e ‘he read’
had̪-iːɺ-e ‘he said’
sameh-iːɺ-e ‘he forgave’

b. sul-iːl-e ‘he wanted’
owel-eːl-e ‘he swam’
gir-iːl-e ‘he moved’
mer-eːl-e ‘he turned about’

c. faðiɺ-eːl-e ‘he preferred’
gulguɺ-iːl-e ‘he did’

The liquid-to-liquid interactions in Mwiini are limited to suffixal /ɺ/; there are no root-internal effects, nor do roots and prefixes interact (50a). Furthermore, the interactions are strictly transvocalic, as suffixal /ɺ/ remains unchanged if the preceding liquid is further away (50b).

(50) Mwiini: limitations of [ɺ] ~ [l] alternations (Kisseberth & Abasheikh 1975)

a. -laːɺ-a ‘be sick’
li-ɺe ‘tall’ (with prefix /li-/)
-ɺaːɺ-a ‘sleep’
ɺeːɺo ‘today’

b. laz-iːɺ-e ‘he went out’
rag-iːɺ-e ‘he was late’
ɺim-iːɺ-e ‘he cultivated’

Kisseberth & Abasheikh (1975) refer to the /ɺ/ → [l] change as ‘lateralization’, but that term is hardly appropriate if /ɺ/ is already lateral, as their articulatory description implies (it is articulated ‘without any lateral contact’). Instead, the crucial difference between [ɺ] and [l] seems to be in the ‘ballistic’ character of the former. It is far from clear how the phonetic distinction between taps and their non-tap counterparts (stops, trills, etc.) are best represented in featural terms. If we suppose, for the sake of the argument, that taps (and flaps) are specified as [+ballistic], then the natural class of liquids in Mwiini consists of [–ballistic] /l, r/ and

berth & Abasheikh (1975:257), there are a fair number of such exceptions, all of which are loans from Arabic or Somali. However, since mutation is not triggered by applicative /-iɺ-/, the /ɺ…ɺ/ → [ɺ…l] dissimilation is presumably robustly manifested in that suffix after native /ɺ/-final roots as well. Kisseberth & Abasheikh (1975) cite no data bearing on this question.

[+ballistic] /ɺ/. The feature [±lateral] groups /l, ɺ/ together as [+lateral] in contrast to /r/, which is [–lateral]. The alternations in (49a–c) could then be interpreted as a combination of harmony and dissimilation. On the one hand, a [+ballistic] liquid (namely /ɺ/) harmonizes with a preceding [–ballistic] liquid (/l, r/), while preserving its [+lateral] specification: hence /l…ɺ/ → [l…l] and /r…ɺ/ → [r…l] (49b). On the other hand, in sequences of two [+ballistic] segments, the second dissimilates, becoming [–ballistic], again preserving its [+lateral] specification: /ɺ…ɺ/ → [ɺ…l]. Similar kinds of dissimilation in tap…tap sequences are attested elsewhere: in the Papuan language Yimas, for example, a /ɾVɾ/ sequence dissimilates to [ɾVt] (Foley 1991:54; cf. Odden 1994).[62]

To conclude, the empirical observations regarding liquid harmony can be summarized as follows. Harmony interactions can hold between liquids and non-liquids; more specifically, between (coronal) liquids and palatal ('coronal'?) glides. When such harmony produces alternations, the effect may either be liquid → glide (Basaa) or glide → liquid (Pare). Harmony may also hold between (coronal) liquids that differ in some property. This is most robustly attested for the [±lateral] distinction, resulting in lateral → rhotic (Bukusu) or rhotic → lateral (Atsugewi, Sundanese); Pare also involves agreement in [±lateral], in addition to the change glide → liquid. Harmony interactions among liquids may also be based on [±ballistic] (or whatever other feature defines taps and flaps as a class), if the Mwiini [ɺ] ~ [l] alternations can in fact be viewed as partly due to consonant harmony.

2.4.6. Stricture Harmony

For the purposes of this survey, the manner of articulation parameter of (oral) constriction degree will be referred to by the term 'stricture'. With respect to stricture, consonants can be arranged on a scale: stop (> affricate) > fricative > approximant. As a category, stricture harmony refers to any long-distance assimilatory interactions, or assimilatory co-occurrence restrictions, that involve segment types occupying contiguous steps on this stricture scale.

Though stricture harmony is unambiguously attested, it is extremely rare in the world's languages. The best example involves the stop vs. fricative contrast, and is found in the Oceanic language **Yabem** (Dempwolff 1939, Bradshaw 1979, Ross 1995). The segmental inventory of Yabem contains only one fricative, /s/, which occurs in the 3Pl prefix /se-/ as well as in roots. The /s/ of the /se-/ prefix assimilates to a root-initial alveolar stop, as illustrated in (51). Ross (1995) notes that stricture harmony is optional in present-day Yabem, but argues that this optionality is a relatively recent development.

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[62] Odden (1994) chooses to interpret this dissimilation as involving [±lateral] instead, based on Foley's observation that the segment represented here as /ɾ/ varies freely between [ɾ] and an apical [l]. Odden thus interprets Yimas /ɾ/ as being phonologically [+lateral].

(51) Yabem: stricture harmony in 3Pl /se-/ prefix (Ross 1995)

a.	sé-líʔ	'they see'	
	sé-gàb^{w}àʔ	'they untie (realis)'	[inferred from discussion]
	sé-kátóŋ	'they make a heap'	[inferred from discussion]
b.	té-táŋ	'they weep'	(~ [sé-táŋ])
	tɛ́-tɛ́ŋ	'they ask, beg'	(~ [sɛ́-tɛ́ŋ])
	dè-dèŋ	'they move towards (realis)	(~ [sè-dèŋ])
	dè-^{n}dèŋ	'they move towards (irrealis)'	(~ [sè-^{n}dèŋ])

Dempwolff (1939), Bradshaw (1979) and Ross (1995) all clearly state that the /s/ of the /se-/ prefix only assimilates to a following stop in case it is alveolar. Yabem stricture harmony can thus be interpreted as place-dependent, applying only to homorganic fricative…stop sequences (recall that /s/ is the only fricative in Yabem). The stricture harmony seen in (51) is strictly transvocalic, in that only root-initial stops trigger assimilation, not root-internal ones (as in /-létí/ 'run'). Finally, the harmony is asymmetric, in that a prefixal /t/ or /d/ does not assimilate to a root-initial /s/. For example, the 1Pl (inclusive) prefix /ta-/ is always realized as [tá-] or [dà-], never as [sá-] or [sà-] (cf. [dà-sùŋ] 'we (incl.) push', [tá-sèlèŋ] 'we (incl.) wander').

Though Yabem stricture harmony almost always results in total identity (such that /s…t/ → [t…t], /s…d/ → [d…d]), this is merely an accidental by-product of the independent patterns of tone spreading and tone-voicing interaction that hold in Yabem (Hansson 2004b; see §3.3.2 below for details). When the /se-/ prefix attaches to a disyllabic root, such that it falls outside the scope of (foot-bounded) tone spreading, it is realized as [té-] regardless of whether the root-initial harmony trigger is voiceless [t] or voiced [d]. This is shown by examples like /se-táké/ → [té-táké] 'they frighten' vs. /se-dàgùʔ/ → [té-dàgùʔ] 'they follow (realis)' (both from Dempwolff 1939).

Interestingly, the descriptions by Dempwolff (1939) and Ross (1995) differ with respect to the interaction of stricture harmony and the prenasalization which marks irrealis mood (on the latter, see §2.4.4 above). According to Ross (1995), prenasalized [^{n}d] triggers stricture harmony no less than non-prenasalized [d], as the last two forms in (51b) illustrates. Dempwolff (1939), however, states explicitly that stricture harmony is *not* triggered by a prenasalized stop, and gives the last two forms in (51b) as 3Pl realis [dè-dèŋ] vs. 3Pl irrealis [sè-^{n}dèŋ] (not [dè-^{n}dèŋ]). Dempwolff also cites other similar pairs: realis [dè-dèʔ] vs. irrealis [sè-^{n}dèʔ] 'they dislike', realis [té-dàgùʔ] vs. irrealis [sé-^{n}dà^{ŋ}gùʔ] 'they follow'. The discrepancy between the descriptions of Dempwolff (1939) and Ross (1995) must either reflect a dialect difference of some kind or else a diachronic change (a levelling of the [dè-] or [té-] alternants from the corresponding realis forms) during the period separating the two accounts.

In addition to the overt stop ~ fricative alternations in (51), Yabem stricture harmony is also manifested root-internally as a static co-occurrence restriction. Native morphemes do not contain /s…t/ or /s…d/ sequences (Dempwolff 1939, Bradshaw 1979, Ross 1995). As before, the co-occurrence restriction is place-dependent; non-homorganic fricative…stop sequences are allowed (/sákíŋ/ 'service', /sàgìŋ/ 'house partition', /sàbʷàʔ/ 'potsherd; spleen').

A more dubious case of stricture harmony alternations, this time involving the fricative–approximant distinction, is the Bantu language **Shambaa** (Kishambaa, Shambala; Besha 1989). In Shambaa, the near-past tense suffix /-ije/ surfaces as [-ize] after 'stems which end in fricatives' (Besha 1989:194), as shown in (52a–b). Although it is clear from the surrounding context that Besha is referring to fricatives in general, the few examples she cites—repeated here as (52b)—all contain one of the *coronal* fricatives /s, z, ʃ/ (Shambaa lacks /ʒ/). Odden (1994) alludes to the Shambaa alternation as involving assimilation between a stem-final consonant and a suffixal glide /j/. However, it is far from clear that this interpretation is justified. As the examples in (52c–d) show, not only does /j/ fail to change to [z] after certain non-coronal stem-final fricatives, but even after certain stems with final /z/, where one would have expected harmony to apply.

(52) Shambaa: stricture harmony in near-past suffix /-ije/? (Besha 1989)

a.	-kant-ije	'wore'
	-ʃind-ije	'during the whole day (past)' [aspectual auxiliary verb]
	-dik-ije	'cooked'
b.	-goʃ-ize	'slept'
	-gwiʃ-ize	'dropped'
	-kas-ize	'roasted'
	-toz-ize	'held'
c.	-aɣ-ije	'got lost'
	-iv-ije	'heard'
d.	-iz-ije	'came'

To gain a better understanding of what motivates the Shambaa [j] ~ [z] alternations, it is helpful to examine similar alternations in the cognate suffixes (< Proto-Bantu perfective **-i̧d-e*) in other Bantu languages. Odden (1994) cites **Pare** (Kipare, Asu; see §2.4.5 above)—a language closely related to Shambaa—as also displaying transvocalic consonant assimilations which might potentially count as stricture harmony. In Pare, just as in Shambaa, the perfective suffix has the shape /-ije/. According to Odden's description, the [j] of this suffix optionally becomes [ɟ] (perhaps [dʒ]; Odden describes it as a 'palatal stop') just in case the preceding stem ends in any of the 'palatal' segments /ɟ, ʃ, ɲ/. This is illustrated in (53). Odden (1994) cites the forms in (53c) as evidence that the assimilation—if that is what it is—is strictly transvocalic; it is not triggered by a root-internal or root-initial palatal.

(53) Pare: stricture harmony in perfective suffix /-ije/? (Odden 1994)

a.	-tet-ije	‘said (perf.)’	
	-kund-ije	‘liked (perf.)’	
	-dik-ije	‘cooked (perf.)’	
	-von-ije	‘saw (perf.)’	
b.	-oɟ-iɟe	‘washed (perf.)’	(~ [-oɟ-ije])
	-banɟ-iɟe	‘healed (perf.)’	(~ [-banɟ-ije])
	-vuʃ-iɟe	‘put up (perf.)’	(~ [-vuʃ-ije])
	-maɲ-iɟe	‘knew (perf.)’	(~ [-maɲ-ije])
c.	-ɟeŋg-ije	‘built (perf.)’	(not *[-ɟeŋg-iɟe])
	-ʃig-ije	‘left behind (perf.)’	(not *[-ʃig-iɟe])

It is possible to interpret the [j] ~ [ɟ] alternation as stricture harmony on the following assumptions. Firstly, with respect to the stricture scale, nasals count as stops (the critical parameter is *oral* constriction degree). Secondly, Pare does not allow [ʒ] in its surface inventory (ruling out /ʃ…j/ → *[ʃ…ʒ] as a possibility). To the extent that these assumptions are justified, the [j] ~ [ɟ] alternation could be seen as place-dependent stricture harmony: a palatal approximant /j/ assimilates in stricture (i.e. becomes an obstruent) when preceded by a homorganic (i.e. ‘palatal’) obstruent.

Pare displays the exact same alternation pattern in the /j/ of the applicative suffix /-ij-/ (from Proto-Bantu *-*id*-), as shown in (54).

(54) Pare: stricture harmony in applicative /-ij-/? (Odden 1994)

a.	-tet-ij-a	‘say for’	
	-big-ij-a	‘beat for’	
	-dik-ij-a	‘cook for’	
b.	-oɟ-iɟ-a	‘wash for’	(~ [-oɟ-ij-a])
	-miɲ-iɟ-a	‘press for’	(~ [-miɲ-ij-a])
c.	-ɟiŋk-ij-a	‘run away for’	(not *[-ɟiŋk-iɟ-a])
	-ʃukum-ij-a	‘push for’	(not *[-ʃukum-iɟ-a])

Yet another example of a similar alternation involving the Bantu perfective suffix (< Proto-Bantu *-*i̧d-e*) is found in Mwiini (Chimwiini; Kisseberth & Abasheikh 1975, Kenstowicz & Kisseberth 1979, Hyman 1993; cf. §2.4.5 above). The Mwiini case can hardly be argued to be an instance of stricture harmony, however. It is mentioned here only because it might shed light on the somewhat puzzling Shambaa and Pare facts.

In Mwiini, the perfective suffix has a bipartite structure, /-iːɺ-e/ (for discussion of the lateral tap [ɺ], represented as ‘ƚ’ by Kisseberth & Abasheikh 1975, see §2.4.5). As in Shambaa, the consonant of this suffix surfaces with [z] when the root ends in a certain class of consonants (55a–b). In Mwiini, that class consists of the (coronal) fricatives /s, z, ʃ/ and the palatal nasal /ɲ/. Kisseberth & Abasheikh (1975) formalize the process in (55b) as a rule of 'stridentization'. As a further complication, only underived [s, z, ʃ] trigger stridentization. Fricatives that are derived from underlying stops by so-called 'consonant mutation' (triggered by the perfective suffix) do not cause /ɭ/ → [z] in the suffix (55c).[63] In addition, there are a few exceptional roots ending in underlying /s, z/ that unexpectedly fail to trigger the process (/-asis-/ 'found an organization', /-bariz-/ 'attend a meeting').

(55) Mwiini: stricture alternations in perfective /-iːɭ-e/ (Kisseberth & Abasheikh 1975)

a.	kun-iːɭ-e	'he scratched'	
	rag-iːɭ-e	'he was late'	
	tij-iːɭ-e	'he feared'	
	d̪od̪-eːɭ-e	'he complained'	
b.	kos-eːz-e	'he made a mistake'	
	anz-iːz-e	'he began'	
	t̪oʃ-eːz-e	'he thought'	
	faɲ-iːz-e	'he did'	
c.	giːs-iɭ-e	'he pulled'	(/-giːt̪-/ 'pull')
	ɭoːnz-iɭ-e	'he begged'	(/-ɭoːmb-/ 'beg')
	poːnz-eɭ-e	'he pounded'	(/-poːnd-/ 'pound')
	piʃ-iɭ-e	'he cooked'	(/-pik-/ 'cook')

The sensitivity to underlying vs. derived status, combined with the peculiar make-up of the class of triggers (/s, z, ʃ/ and /ɲ/), casts some doubt on the interpretation of the Mwiini [ɭ] ~ [z] alternation as assimilation (consonant harmony). Hyman (1993:222, n. 14) offers an alternative explanation, suggesting that '[i]t is likely that verb roots that end in /s, z, š, ɲ/ actually involve an underlying final *-i-* that combines with the perfective to form CVC-*iɫ-i-e* sequences' (see also Hyman 1994:86, n. 8). The idea is that this stem-final /-i-/ is what triggers the /ɭ/ → [z] change. The 'interfixation' of the /-iC-/ portion of the perfective suffix is a well known phenomenon in the Bantu family (Bastin 1983, Hyman 2003). In many languages, the insertion of /-iC-/ into the middle of a /CVC-i-/ structure results in a cyclicity effect, in that the /-i-/ triggers changes (spirantization, etc.) in both the root-final consonant and the suffix consonant. This is illustrated by the examples from Bemba in (56); 'į' represents a mutation-triggering [i] vowel.[64]

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[63] The forms in (55c) show an independent vowel length alternation which is not relevant in the present context (for discussion of shortening and its problematic interaction with mutation, see Kisseberth & Abasheikh 1975, Hyman 1993).

[64] In the interest of exposition, the representations in (56) are slight abstractions, following Hyman (1994). The fricative /s/ is realized as [ʃ] before [i]. Moreover, before a vowel, the

(56) Bemba: multiple consonant mutation (Hyman 1994, 2003)

a.	-buːk-	'get up (intr.)'	
	-buːs-i̧-	'get [smn] up'	(caus. /-i̧-/)
b.	-buːk-il-	'get up for/at'	(applic. /-il-/)
	-buːs-is-i̧-	'get [smn] up for/at'	(caus. /-i̧-/ + applic. /-il-/)
c.	-buːk-il-e	'got up' [inferred from disc.]	(perf. /-il-e/)
	-buːs-is-i̧-e	'got [smn] up'	(caus. /-i̧-/ + perf. /-il-e/)

As illustrated in (56b), when the applicative suffix /-il-/ is 'interfixed' into a causativized verb stem, the causative suffix /-i̧-/ causes mutation in the root-final consonant as well as in the suffix consonant to which the /i̧/ vowel is adjacent on the surface. The example in (56c) shows that the same happens with perfective /-il-e/, where the /-il-/ portion of that morpheme is similarly interfixed. As Hyman (1994) points out, forms with such double mutation may superficially appear to be due to assimilation—that is, a kind of consonant harmony (see Kula 2002)—but this interpretation is contradicted by forms like [-las-il-] 'wound for/at' from /-las-/ 'wound' (with underlying /s/). Hyman analyzes double mutation in Bemba as a *cyclicity* effect resulting from morphology-phonology interleaving, by invoking cyclic rule application. From an alternative perspective, the 'mutated' [s] (or [ʃ]; see n. 64) could be transmitted from the simple causative in (56a) to the applicativized or perfective causative forms in (56b) and (56c) by means of output-output correspondence (Benua 1995, 2000).

Hyman's suggestion, then, is that such 'interfixation' with double mutation (as a cyclicity effect) is the source of the [ɺ] ~ [z] alternation in the Mwiini perfective as well.[65] Whether the same reinterpretation can be extended to the putative cases of stricture harmony in Shambaa and Pare as well is less clear. Although that question cannot be answered confidently at this point, the Shambaa facts in (52) suggest that such an analysis might be feasible for that particular case. The Pare [j] ~ [ɟ] alternation, on the other hand, remains a strong contender for counting as a genuine example of stricture harmony. The main reason is that the [j] of the relevant verbal suffixes in Pare is subject to an assimilatory alternation in [±lateral] as well, surfacing as [l] and [r] after root-final [l] and [r], respectively. This [j] ~ [l] ~ [r] alternation, which was discussed in §2.4.5 above, can only be accounted for as a process of transvocalic

mutation-triggering /-i̧-/ surfaces as a glide [j], but merges with a preceding /s/ to yield [ʃ]. A surface form like '[-buːs-is-i̧-e]' in (56c) is thus actually pronounced [-buːʃiʃe].

[65] Although this is very likely the *diachronic* source of the [ɺ] ~ [z] alternation in Mwiini, a potential problem for a *synchronic* analysis in these terms is the fact that all verb roots with underlying /s, z, ʃ, ɲ/ trigger the /ɺ/ → [z] change in Mwiini, even borrowings such as /-bus-/ 'kiss', /-xus-/ 'be concerned', /-his-/ 'feel cold' (all from Arabic). In order for a synchronic cyclicity analysis to be tenable, all verbs ending in any of these segments would have to be interpreted (by Mwiini speakers/learners) as 'pseudo-causatives' in the sense of Hyman (2003), with a covert morphological structure /CVC-i-/ rather than /CVC-/.

consonant harmony (liquid harmony). The fact that /j/ does display consonant harmony alternations in such cases lends support to the view that the Pare [j] ~ [ɟ] alternation is likewise due to harmony. Furthermore, the latter patterns with the [j] ~ [l] ~ [r] alternation in that both are optional, with non-harmonized [j] being acceptable in all contexts. In sum, it seems quite plausible that Pare should indeed count as a case of (place-dependent) stricture harmony.

Tentative though the Pare case may be, the existence of stricture harmony as a type is solidly confirmed by the Yabem [s] ~ [t] ~ [d] prefix alternations discussed earlier in this section. Recall that in Yabem, the alternation was mirrored by a static co-occurrence restriction banning morpheme-internal */s…t/ and */s…d/ sequences as well. This raises the question whether other languages might display stricture harmony solely as a morpheme structure constraint.

One example is the Mayan language **Yucatec** (Straight 1976, Lombardi 1990, Noguchi 2007) which seems to have a root-level stricture harmony which regulates the co-occurrence (and sequencing) of coronal affricates with coronal fricatives and stops. First, note that Modern Yucatec has inherited from Classical Yucatec a root-level coronal harmony (§2.4.1.1) which rules out the root-internal co-occurrence of alveolar and postalveolar sibilants (*/s…ʃ/, */tʃ…s/, */ts'…tʃ/, etc.; Lombardi 1990:389–391).

With respect to the stricture harmony patterns, the following exposition follows Noguchi (2007), whose statistical study is based on the dictionary of Bricker et al. (1998). In some respects, Noguchi's findings differ slightly from the descriptions given in earlier works (Straight 1976, Lombardi 1990), which were the basis of the corresponding section of Hansson (2001b). The general pattern is a restriction on the co-occurrence of pulmonic (i.e. non-ejective) coronal affricates and pulmonic coronal stops and fricatives. The effect is directional, in that while affricate…fricative and affricate…stop sequences of the relevant kind are ruled out, the reverse sequences do occur (with a few exceptions).

(57) Yucatec: root-internal stricture harmony (Noguchi 2007)[66]

a. Co-occurrences of pulmonic coronal obstruents:

ts…ts	(*)s…ts	(t…ts)	s…t	t…s
tʃ…tʃ	ʃ…tʃ	t…tʃ	ʃ…t	t…ʃ
s…s				
ʃ…ʃ				
t…t				

[66] There are no examples of roots with a /s…ts/ sequence, and only one example of /t…ts/ (/tíʔits/ 'corner'); it is unclear whether this underrepresentation is systematic or accidental. The absence of /s…ts/ was true in Classical Yucatec as well (as Noguchi 2007 points out, the claim by Lombardi 1990:391 that /sVts/ roots are attested in McQuown 1967 is erroneous).

b. Prohibited sequences of pulmonic coronal obstruents
*ts…s *ts…t
*tʃ…ʃ *tʃ…t

The co-occurrence restriction in (57b) is dependent on identity in laryngeal features. Ejective affricates freely combine with (non-ejective) fricatives (/tʃ'oʃ/ 'sit cross-legged', /ts'is/ 'copulate'), as well as with pulmonic stops (/ts'it/ 'extract', /ts'úʔut/ 'stingy', /tʃ'iːt/ 'bamboo').[67] Ejective affricates and ejective stops do not co-occur in either order (*/t'…tʃ'/, */ts'…t'/), but this likely reflects a more general requirement that co-occurring ejectives be identical in all respects (see §2.4.7 and §2.4.8).

It is not entirely clear whether it is appropriate to view the ordering restriction seen in (57) as a case of stricture harmony, but this is certainly a possible interpretation. Under such an analysis (which is implemented formally in Noguchi 2007, using the analytical framework described in chapters 4 and 5 below), the root-level stricture harmony is a strictly *anticipatory* relation (see §3.1), dependent on identity in place of articulation and laryngeal features, which prohibits the co-occurrence of affricates with segments that are adjacent to them on the stricture scale. Such stricture harmony would have effects like /ts…s/ → [s…s] and /tʃ…t/ → [t…t]. The fact that sequences like /t…ts/, /ʃ…tʃ/ are unaffected might be accounted for on the grounds that contour segments (affricates) are more marked than non-contours (stops, fricatives), by assuming that Yucatec allows 'deaffrication' (/ts, tʃ/ → [t], /ts/ → [s], /tʃ/ → [ʃ]), but not 'affrication' (/s, t/ → [ts], /ʃ, t/ → [tʃ]).[68] This would be somewhat analogous to the alveolar vs. postalveolar asymmetry observed in various sibilant harmony systems, whereby alveolar…postalveolar sequences like /s…ʃ/ harmonize to [ʃ…ʃ] while postalveolar…alveolar sequences like /ʃ…s/ remain unassimilated (the so-called 'palatal bias'; see chapter 6).

Stricture harmony patterns akin to that of Yucatec seem to occur elsewhere in the Mayan family as well. In **Chol** (Gallagher 2008, Gallagher & Coon 2009), pulmonic fricatives and affricates do not co-occur. Here linear order does not matter: unlike in Yucatec, the coronal fricative…affricate sequences */s…ts/ and */ʃ…tʃ/ are unattested just like */ts…s/ and */tʃ…ʃ/. (Two counterexamples with /tʃ…ʃ/ exist, but Gallagher & Coon suggest that these might belong to a special stratum in the Chol lexicon.) The co-occurrence of ejective affricates with fricatives is unrestricted in Chol, just as it is in Yucatec. Chol differs in Yucatec, however, in that the stop /t/ (which is palatalized [tʲ] in Chol) freely co-occurs with the affricates /ts, tʃ/; stricture harmony pertains only to the sibilants /s, ʃ, ts, tʃ/.

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[67] Curiously, pulmonic affricates do not appear to combine as freely with the ejective stop /t'/ in Yucatec. Both /ts…t'/ and /tʃ…t'/ are unattested, as is /t'…ts/ (though there are several examples of /t'…tʃ/, e.g. /t'utʃ/ 'to perch').

[68] Noguchi (2007) instead builds the asymmetry directly into the definition of his constraint IDENT(stric)-C_1C_2 which drives stricture harmony (on the IDENT[F]-CC notion, see chapter 4), by restricting it to $C_1 \ldots C_2$ pairs in which C_2 is a stop or a fricative (not an affricate)

Other possible cases of stricture harmony involving homorganic (coronal) stops and affricates are those languages from §2.4.1.2 above where sequences like /t…tʃ/ are prohibited or actively assimilated to [tʃ…tʃ]. One such case is **Bolivian Aymara**. Based on a search of de Lucca (1987), MacEachern (1999) observes that root-internal sequences like /tʰ…tʃʰ/, /tʃʰ…tʰ/, /t'…tʃʰ/, /tʃ'…tʰ/—which are otherwise well-formed, conforming to the laryngeal co-occurrence restrictions operative in the language (see §2.4.8)—do not occur. Based on this fact, and the apparent lack of any roots combining velars and uvulars (see §2.4.2), she tentatively suggests that morphemes in Bolivian Aymara may be governed by 'prohibitions on the co-occurrence of similar, but non-identical coronal and back lingual articulations' (MacEachern 1999:48). While MacEachern deals only with co-occurrences of laryngeally specified plosives (ejectives and aspirates), the co-occurrence restriction is asymmetric when one (or both) of the plosives is laryngeally unspecified /t/ or /tʃ/, as detailed in §2.4.1.2 above. For such combinations of coronal plosives, the pattern is a mirror image of the Yucatec one: stop…affricate sequences are banned, but affricate…stop sequences are allowed.

Other cases analogous to Bolivian Aymara are **Pengo** (Burrow & Bhattacharya 1970) and **Kera** (Ebert 1979), both of which display long-distance assimilations of the type /t…tʃ/ → [tʃ…tʃ], as detailed in §2.4.1.2 above. It is conceivable that sound patterns like these should be classified as stricture harmony, rather than as a subtype of coronal harmony, given that the stops and affricates also differ along the dimension of dental/alveolar vs. postalveolar place of articulation. The motivation for the classification of these cases as coronal (non-sibilant) harmony, rather than stricture harmony, is twofold. Coronal harmony is vastly more common than any other subtype of consonant harmony, making it an *a priori* more plausible category. Secondly, these cases display the very same 'palatal bias' as shapes the typology of coronal sibilant harmony systems; see chapter 6 for detailed discussion.

2.4.7. Laryngeal Harmony

Another set of phonological features (and articulatory gestures) that may form the basis of consonant harmony interactions are those pertaining to laryngeal properties, namely phonation type (voicing, aspiration) and airstream mechanism (ejectives and implosives vis-à-vis pulmonic consonants). Laryngeal consonant harmony is fairly robustly attested, though most of the reported cases involve static co-occurrence restrictions on root morphemes, rather than overt alternations. For an excellent study of (static) assimilatory and dissimilatory laryngeal co-occurrence restrictions, see MacEachern (1999), which is the source of much of the information reported here. The treatment of individual cases in this section often differs somewhat from that in MacEachern's work. This is mostly due to the fact that the present study is limited to those co-occurrence restrictions that are assimilatory in nature. Also, the overview in this section is exclusively concerned with restrictions on the co-occurrence of segments that differ in *laryngeal* features. Many of the languages mentioned here and in MacEachern (1999) exhibit additional assimilatory requirements, whereby segments that match in some laryngeal feature must be completely identical—that is, must agree in place of articulation as well. This issue will be ignored here, but is taken up again in §2.4.8.

There are very few attested cases of laryngeal harmony resulting in alternations appear to be attested. One potential example, **Yabem** (Oceanic), is discussed in detail in §3.3.2 below, and argued to be due to tone-spreading and tone-voicing interdependence, rather than laryngeal harmony as such (see Hansson 2004b). An oft-cited case of laryngeal harmony alternations is the East Chadic language **Kera** (Ebert 1979, Odden 1994, Walker 2000a, 2001, Hansson 2004, Rose & Walker 2004, Uffmann 2005, Pearce 2005, 2006, 2009). In Kera, voiced and voiceless plosives do not generally co-occur within a word. In particular, if the root contains a voiced plosive (stop or affricate), plosives in affixes will surface voiced as well. As (58) clearly shows, this voicing agreement is bidirectional, affecting prefixes and suffixes alike.

(58) Kera: laryngeal harmony alternations (Ebert 1979)

a. Voicing harmony in nominal prefix /k-/[69]

kə-màanə̀	‘woman’
kə-taːtá-w	‘cooking pot (plur.)’
kə-kámná-w	‘chief (plur.)’
ɡə-dàːrə̀	‘friend’
ɡə-dàjɡá-w	‘jug (plur.)’

b. Voicing harmony in feminine suffix /-ká/

sár-ká	‘black (fem.)’
dʒàr-ɡá	‘colorful (fem.)’

c. Bidirectional voicing harmony (collective /-káŋ/, masculine /-kí/)

kə-sár-káŋ	‘black (coll.)’
kí-sír-kí	‘black (masc.)’
ɡə-dʒàr-ɡáŋ	‘colorful (coll.)’
ɡi-dʒìr-ɡì	‘colorful (masc.)’

Kera laryngeal harmony gives the appearance of being parasitic on identity in stricture, requiring both trigger and target to be plosives. Fricatives and plosives do not seem to interact, as is evidenced by forms like /fɛ̀rɡé/ ‘to itch’, /dɛ̀fé/ ‘to make sauce’ (Ebert 1979:9). However, the failure of fricatives to participate in voicing harmony seems to be due to a fairly recent (and to some extent ongoing) merger of voiced fricatives with their voiceless counterparts (such that /fɛ̀rɡé/ < **vɛ̀rɡé*, /dɛ̀fé/ < **dɛ̀vé*; Pearce 2005 gives the former as [vɛ̀rɡɛ̄]). At an earlier historical stage, then, voicing harmony in Kera appears to have encompassed fricatives as well as stops. Sonorants (which are redundantly voiced) do not trigger voicing harmony. Interestingly, neither do (voiced) implosives (see Hansson 2004a for discussion).

[69] The vowel surfacing in this prefix is epenthetic, its quality determined by vowel harmony.

Although it is clear that Kera voicing agreement goes beyond strictly transvocalic interactions, as it can cross an intervening sonorant consonant as well, Ebert (1979) does not contain any forms that might help determine whether the trigger and target are required to be in adjacent syllables, or whether the domain of voicing harmony is unbounded. Uffmann (2005) points out /təːrən-ɡa/ → [təːrəŋka] 'old (fem.)' as possible evidence of long-range assimilation, but Pearce (2005) rejects the analysis of the suffix in this form as being underlyingly /-ɡa/ (rather than /-ka/). In addition, this form would be highly unusual in that it would involve active assimilation in [–voice] rather than [+voice]. It appears that Kera laryngeal harmony is asymmetric, with voiceless plosives becoming voiced but not vice versa: there is no indication that underlyingly voiced plosives in affixes ever become voiceless under the influence of a voiceless plosive in the adjacent root.

While the above characterization is how the Kera voicing alternations have standardly been interpreted in the phonological literature (most recently by Archangeli & Pulleyblank 2007), it has not gone unchallenged. The possible diachronic origins of voicing harmony systems are explored in Hansson (2004a), where it is argued that Kera long-distance voicing assimilation most likely arose by analogical reanalysis of superficial 'agreement' patterns resulting from tone spreading and tone-voicing interaction (much as in Yabem; see §3.3.2 and Hansson 2004b). Vowels intervening between two interacting (voiced) stops always happen to be low-toned, and examples exist in which an intervening high-toned vowel appears to block the harmony ([k-əɡaj] 'hoes', [k-əɡàmlà] 'bulls', as opposed to [ɡ-àzrá-w] 'gazelles', [ɡə̀-dàːrà] 'friends'; all have plural /k-/). Pearce (2005, 2006, 2009) takes this account one step further, arguing at length that tone spreading and tone-voicing interaction is *synchronically* responsible for the apparent voicing assimilation patterns. On the basis of phonological, acoustic, and perceptual evidence, Pearce (2009) concludes that voicing is not contrastive in Kera (in most dialects/sociolects), and that Voice Onset Time (VOT) values are predictable from tone. For example, Pearce points out that voicing alternations can be directly conditioned by tone, with no 'harmony-triggering' obstruent present. Thus habitual /-t-/ surfaces as [-d-] before a low-toned vowel; contrast /lɔ̀ɓ-t-n/ → [lɔ̀ɓdɔ̀n] 'I fatten' with /lɔɓ-t-n/ → [lɔ̄ɓtɔ̄n] 'I convince', /lɔ̀ɓ-t-á/ → [lɔ̀ɓtá] 'she fattens', /lɔɓ-t-á/ → [lɔ́ɓtá] 'she convinces'. In sum, it seems that the apparent long-distance voicing assimilations of Kera are illusory, in much the same way as the Yabem sound pattern discussed at length in §3.3.2 below. It is possible, however, that for those urban varieties of Kera where VOT is contrastive (and tone may not be contrastive at all, e.g. for urban female speakers), voicing harmony is the appropriate synchronic characterization.

Alternations due to voicing harmony are also found in a great many Berber languages, where they affect the fricative /s/ in derivational prefixes, especially the causative /s(ː)-/ prefix. The Berber sibilant voicing alternations will here be described only in brief, as they are discussed in much more detail in §3.2.2.2 below. The basic pattern is illustrated in (59) for the Tamajaq variety of **Tuareg** (Southern Berber) spoken in Niger (Alojaly 1980; for other Tuareg dialects, see Sudlow 2001, Heath 2005). The same patterns are found in many Northern Berber varieties as well, such as **Tashlhiyt** (Elmedlaoui 1995a, Lahrouchi 2003) and at least some varieties of **Tamazight** (Penchoen 1973). Note that sibilants are subject to coronal ([±anterior]) harmony as well as voicing harmony.

(59) Tamajaq Tuareg: sibilant voicing and anteriority harmony (Alojaly 1980)

	Base		*Causative*	
a.	əlməd	'learn, study'	s-əlməd	'teach, inform'
	busu	'be injured'	s-əbːusu	'injure'
b.	mă∫ăn	'be overwhelmed'	∫-əmːə∫ən	'overwhelm'
	fərə∫ːət	'be ugly, humiliated'	∫-əfːərə∫ːət	'make ugly, humiliate'
	əɣ∫əd	'destroy, spoil'	∫-əɣ∫əd	'cause to spoil'
c.	əntəz	'pull out, extract'	z-əntəz	'cause to extract'
	əbzəg	'be mad, panic'	z-əbzəg	'drive mad, cause to panic'
	guləz	'be left, remain'	z-əgːuləz	'cause to remain'
d.	kuʒət	'saw (v.)'	ʒ-əkːuʒət	'cause to saw'
	əgʒəʒ	'crave, insist'	ʒ-əgʒəʒ	'cause to crave'
	ăɣʒu	'be amazed'	ʒ-ăɣʒu	'amaze'

The interaction in (59c–d) is clearly a long-distance assimilation between sibilants specifically. Voiced obstruents other than sibilants do not trigger voicing of /s-/ ([s-əɣdər] 'cause to betray', [s-əbːələgləg] 'set on fire',).

The same harmony seems to hold within the root, where sibilants that disagree in voicing (or in anteriority) are not allowed to co-occur. The root-internal voicing harmony generalization appears to be broader, in that pairs of obstruents which differ only in voicing (/t…d/, /g…k/, /χ…ʁ/, etc.) are prohibited (see Elmedlaoui 1995a:32–33 on Tashlhiyt, and Willms 1972:40 on Tamazight).

The harmony effects in (59) always result in complete identity between the co-occurring sibilants.[70] For this reason, and the fact that anteriority harmony and voicing harmony operate over the same class of triggers/targets (namely sibilants), it might be tempting to collapse the two into a single, 'total harmony' of sorts (see §2.4.8; cf. Gallagher 2008, Gallagher & Coon 2009). On this view, co-occurring sibilants would be explicitly required to be identical, rather than to agree in the specific features [±anterior] and [±voice]. However, a 'total-harmony' interpretation of the Berber sibilant interactions is contradicted by the Imdlawn dialect of Tashlhiyt (Elmedlaoui 1995a), in which the voicing harmony—but not the anterior har-

[70] This may not be entirely true. With very few exceptions, Alojaly (1980) transcribes /s-/ as not taking on the pharyngealization of a /zˤ/ or /sˤ/ in the stem: [z-əlfəzˤ] 'cause to squash', [s-əwəsˤ] 'boil (tr.)'. In Sudlow's (2001) description of the Tamajaq and Tamashek varieties of Tuareg spoken in Burkina Faso, the prefix sibilant is transcribed as pharyngealized in such cases ([zˤ-əkːənzˤăr] 'be troubled, sad, upset'), and likewise in Heath's (2005) description of the Tamashek dialects spoken in Mali ([zˤ-ìhəzˤ] 'make approach!').

mony—is blocked by an intervening voiceless obstruent. Thus voicing harmony fails in [sː-ukz] 'recognize', [ʃ-nuqːʒ] (no gloss), [ʃˤ-mˤ-ħˤaˤrˤaˤʒˤ] 'get angry with each other', as opposed to cases like [z-bruzːa] 'crumble', [ʒˤ-gˤrˤuˤʒˤːmˤ] 'be extinguished (in cooking)', where only voiced material intervenes between the two sibilants. This clearly shows that the long-distance voicing assimilation is separate from the anteriority harmony. (For detailed discussion of the blocking effects in Imdlawn Tashlhiyt, see §3.2.2.2 below.)

Returning to the Chadic branch of Afro-Asiatic, laryngeal harmony is attested in languages other than Kera as well, albeit only as a root-internal co-occurrence restriction. (It is possible that these cases, too, are due to tone-voicing interaction, at least historically; Hansson 2004a.) The West Chadic language **Ngizim** (Schuh 1978, 1997) has undergone a historical sound change whereby a voiceless obstruent became voiced when followed by a voiced obstruent (60a). Laryngeal harmony in Ngizim is not sensitive to differences in stricture; fricatives and stops alike participate as triggers and targets. However, the Ngizim harmony is dependent on identity in (other) laryngeal features in that voiced *implosives* fail to trigger voicing in a preceding obstruent (60b). Finally, disharmonic exceptions exist (60c); these are all loanwords from other languages.[71] Except where stated otherwise, the data in (60) are cited from Schuh (1997).

(60) Ngizim: root-internal laryngeal harmony (Schuh 1997)

a. Regressive voicing harmony between pulmonic obstruents

kùtə́r	'tail'		
ɬə̀pú	'to clap' (Schuh 1978:260)		
tàsáu	'to find'		
sə̀tú	'to sharpen to a point' (Schuh 1978:260)		
gâːzá	'chicken'	< **k…z*	(cf. Hausa /kàːzáː/)
də́bâ	'woven tray'	< **t…b*	(cf. Hausa /tàːfíː/ 'palm')
zàbìjú	'clear field'	< **s…b*	(cf. Hausa /sásːàbéː/)
zə̀dù	'six'	< **s…d*	(cf. Hausa /ʃídà/)

b. Voiced implosives do not trigger voicing harmony

pə́ɗə́k	'morning'
kìiɗú	'to eat (meat)'
fə́ɗú	'four' (Schuh 1978:260)
sàpɗú	'to pound'

71 Interestingly, Bade, the language most closely related to Ngizim, displays an anticipatory voicing *dissimilation* under the same conditions (Schuh 1978, 1997). A pulmonic voiced obstruent becomes voiceless when followed by another pulmonic voiced obstruent (e.g. Bade /kádùwáːn/ < **g…d*; cf. Ngizim /gádùwà/, Hausa /gàdáː/). Unlike Ngizim voicing harmony, Bade voicing dissimilation gives rise to voicing alternations in prefixes, at least dialectally (cf. [də̀-ɬávà] 'pierced' vs. [tə́-ɮàwí] 'seated'; Schuh 1978: 267, n. 17).

c. Disharmony in loanwords (lexical exceptions)

tàːbâ	'tobacco'	(from Hausa /táːbàː/)
kàrgûn	'medicine'	(from Kanuri /kùrgûn/)

Ngizim voicing harmony is asymmetric: harmony only targets /T…D/ sequences, not /D…T/, as illustrated in (61). (Here and in what follows, 'T' and 'D' stand for non-implosive obstruents, voiceless and voiced, respectively.)

(61) Ngizim: asymmetric character of voicing harmony (/D…T/ allowed)

a.	bàkú	'roast'	(Schuh 1997)
	dùkʃí	'heavy'	(Schuh 1978: 251)
	gùmtʃí	'chin'	(Schuh 1997)
b.	mbàsú	'sit'	(Schuh 1978:262)
	ŋgàs	'spear'	(Schuh 1978: 263)
c.	zàpə̀nú	'churn'	(Schuh 1978:254)
	zùktú	'pierce'	(Schuh 1978:273)

The fact that /D…T/ is not subject to harmony is evidence of asymmetry along two dimensions. Firstly, there is a *featural* asymmetry. Just as in Kera, only [+voice] obstruents trigger assimilation; there is no regressive 'voicelessness harmony' (e.g. /bàkú/ ↛ *[pàkú]). Secondly, there is a *directional* asymmetry in that the harmony is strictly anticipatory; there is no progressive assimilation in [+voice] (e.g. /bàkú/ ↛ *[bàgú]).

As regards locality, and the maximum distance between the interacting consonants, Schuh (1997) states the voicing assimilation rule as holding between onsets of adjacent syllables (cf. §3.2.2.3). This formulation implies that a coda consonant may intervene between the two without interfering with the harmony (/…TVC.DV…/ → […DVC.DV…]), and also that voicing harmony will *not* apply to a tautosyllabic onset-coda pair (/…TVD.CV…/). Moreover, voicing assimilation is predicted to fail if a syllable intervenes between the two consonants (/…TV.CV.DV…/). Unfortunately, Schuh (1978, 1997) does not cite any forms that could be brought to bear on the question of locality.[72] There are no disharmonic sequences at all of the type [T…D] in the Ngizim data cited. Regardless of the nature or amount of intervening segmental material, the only attested combinations are [T…T], [D…D] and [D…T].

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[72] Schuh (1997) uses the same adjacent-syllable onset restriction in his formulation of the Bade voicing dissimilation rule (see note 71 above). The existence of pairs such as Ngizim /gúmbàk/, Bade /kûmbáːn/ 'lake' (with uncertain etymology, i.e. either < **g…b* or **k…b*) entails that either Ngizim voicing harmony or Bade voicing dissimilation is capable of applying across a coda sonorant. This is equally consistent with a syllable-adjacency restriction and with no restriction at all (unbounded harmony).

The evidence would thus be consistent with the alternative view that Ngizim voicing harmony is unbounded.

Another possible case of voicing harmony is the Dravidian language **Malto** (Mahapatra 1979). Here harmony appears to be restricted to homorganic combinations of dorsal (velar or palatal) plosives. Mahapatra (1979:39–40) states that if a CVC syllable has a voiced velar onset, it cannot have a voiceless velar coda. The same applies to palatal onset-coda combinations. As a result, syllables of the type *[ɡVk] and *[ɟVc] are prohibited, while the reverse [kVɡ] and [cVɟ] appear to be permissible syllables (e.g. [kaɡ.te] 'paper'). Although Mahapatra (1979) states this co-occurrence restriction as applying specifically to *tautosyllabic* dorsal stops, it is possible that it holds for heterosyllabic (tautomorphemic) sequences as well. I have not been able to determine this conclusively, but a brief search of Mahapatra (1979) failed to turn up any counterexamples in CV.CV sequences either. For example, same-voicing sequences like [ka.ke] 'comb' and [ɡo.ɡa] 'stone' seem common, but no [ɡV.kV] or [ɟV.cV] cases were found.

A process of (obstruent) voicing assimilation across an intervening vowel is also described for the Omotic language **Dime** by Seyoum (2008:36–37), where it gives rise to alternations in suffix obstruents. Unfortunately, Seyoum only cites three examples as illustrations: /ʔáʁ-af/ → [ʔáɣaβ] 'trees', /ɡitʃːó-b-is/ → [ɡitʃːóβiz] 'the big one', /ʔámz-is/ → [ʔámziz] 'the woman' (with plural /-af/ and definite /-is/, respectively). Seyoum (2008) describes this process—which he refers to as 'distant voicing'—as being triggered by 'a voiced consonant', and targeting 'a fricative in the next syllable'. However, in all three examples the trigger happens to be fricative as well (in the output), and in all cases the trigger and target are in fact located in the same syllable (onset vs. coda). The example /ʔáɲdʒ-is/ → [ʔáɲdʒiʒ] 'blessing', with the same definite /-is/ suffix, occurs in a different section (p. 37), where the trigger is an affricate rather than a fricative. (On sibilant anteriority harmony in Dime and other Omotic languages, see §2.4.1.1 above.)

In all the cases of laryngeal harmony mentioned so far, the parameter involved has been (obstruent) voicing. Recall also that in Ngizim, harmony is restricted to pulmonic obstruents: voiced implosives do not trigger voicing harmony. Another West Chadic language, **Hausa**, displays a variety of root-level laryngeal harmony restrictions that, among other things, prohibit the co-occurrence of ejective and implosive stops (Parsons 1970, MacEachern 1999). As a natural class, ejectives and implosives are characterized by a glottalic airstream mechanism, and share the phonological feature [+constricted glottis]; they differ only in [±voice]. Thus, the Hausa co-occurrence restriction can be viewed as an instance of voicing harmony, one which is limited to the class of glottalic ([+constricted glottis]) obstruents rather than pulmonic ones.

Other cases of laryngeal harmony exist which specifically target the pulmonic vs. glottalic distinction. An 'airstream harmony' of this kind seems to be characteristic of most Ijoid languages. For example, in **Kalabari Ijo**, voiced implosives and voiced pulmonic stops are not allowed to co-occur within roots (Jenewari 1989), as shown in (62). It is worth noting that Ijo has no ejectives, such that the [±constr. glottis] feature is contrastive only in voiced stops.

(62) Kalabari Ijo: root-internal laryngeal harmony in (Jenewari 1989)

a. Well-formed roots containing multiple voiced stops

bábā	'cut'
ébébé	'talk while sleeping'
badara	'be(come) very wide'
ɓɪɓɪ	'mouth'
ɗáɓá	'lake'
ɗʊ́ɓárí	'stone'

b. Disallowed root-internal combinations

*ɓ…b	*b…ɓ	*ɗ…d	*d…ɗ
*ɓ…d	*b…ɗ	*ɗ…b	*d…ɓ

This type of harmony is attested in other Ijoid languages as well. In his description of **Bumo Izon**, Efere (2001) describes the same phenomenon, stating clearly that it is restricted to labials and alveolars, which are contrastively pulmonic or implosive (/b, d/ vs. /ɓ, ɗ/), just as in the Kalabari Ijo examples above. On the other hand, velar /ɡ/ is redundantly pulmonic in Bumo Izon (no implosive /ɠ/ exists), and labial-velar /ɠ͡ɓ/ is redundantly implosive (no pulmonic /ɡ͡b/ exists). These voiced stops freely co-occur with pulmonic and implosive voiced stops at the labial and alveolar place of articulation, (/ɖúgó/ 'to pursue', /ɠ͡ɓódaɠ͡ɓoda/ '(rain) hard'). The Bumo Izon case is discussed in more detail in §5.3.2 below.

Hausa has a similar restriction against the morpheme-internal co-occurrence of implosives and plain voiced stops, but in Hausa, the harmony is dependent on identity in place of articulation (Parsons 1970, MacEachern 1999). If two co-occurring voiced stops are homorganic, then they must also agree in airstream mechanism: different-airstream pairs are allowed as long as they are heterorganic (e.g. /ɗiga/ 'poured out in drops'), whereas homorganic */ɗ…d/, */b…ɓ/ (etc.) are prohibited.[73] In fact, this voicing-dependent 'airstream harmony' appears to hold for voiceless obstruents as well in Hausa, as voiceless pulmonic stops and ejectives also do not co-occur within roots. The Hausa laryngeal harmony can thus be defined in more general terms as being parasitic on both place and voicing: pulmonic and glottalic stops must not co-occur if they agree in voicing and place of articulation (MacEachern 1999).[74]

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[73] There are several exceptions to this generalization in Hausa, most of which contain the sequence /d…ɗ/. MacEachern (1999:57–58) takes note of this unexpected occurrence of /d…ɗ/, but does not attempt to incorporate it into her analysis of the Hausa laryngeal co-occurrence restrictions.

[74] MacEachern (1999) decides to treat the 'plain' voiceless stops in Hausa as aspirated (based on Voice Onset Time values reported by Ladefoged 1964). This issue is irrelevant in the present context.

A very similar harmony pattern occurs in the Mayan language **Tzutujil** (Dayley 1985, MacEachern 1999). As in many other languages of the Mayan family, only two series of plosives are differentiated in Tzutujil: voiceless unaspirated and 'glottalic' plosives. In Tzutujil, the glottalic plosives are realized as (voiced) implosive at the labial and coronal places of articulation, but as (voiceless) ejective otherwise; glottalic coronal affricates are ejective as well.[75] Based on Dayley (1985), MacEachern (1999) interprets the Tzutujil co-occurrence restriction against homorganic glottalic vs. pulmonic plosives in roots as holding only for ejectives, not implosives. Thus, sequences like */k'…k/ or */ts…ts'/ are ruled out, whereas /ɓ…p/ or /t…ɗ/ are allowed. The rarity of implosive /ɗ/, and the paucity of relevant data in Dayley (1985) makes it hard to determine conclusively if sequences like /ɓ…p/, /t…ɗ/ are truly permissible in Tzutujil. However, if the above characterization is accurate, the pattern is easily accounted for as an 'airstream harmony' that is parasitic on voicing as well as place of articulation, just like the Hausa case.

Laryngeal harmony preventing the co-occurrence of homorganic pulmonic and glottalic plosives (in effect, plain vs. ejective voiceless plosives) is attested elsewhere in the Mayan language family as well. One such example is **Modern Yucatec** (Straight 1976, Noguchi 2007). This absolute co-occurrence restriction has been claimed to be a generalized version of what was merely an *ordering* restriction in **Classical Yucatec** language (Lombardi 1990, based on McQuown 1967), in that homorganic ejective…pulmonic sequences were allowed but pulmonic…ejective ones were banned (/T'…T/, but */T…T'/). However, Noguchi (2007:46 n. 25) casts serious doubt on McQuown's (1967) description about Classical Yucatec co-occurrence patterns, pointing out that nearly all of the C'VC root shapes which McQuown (and Lombardi) claims to occur in the 16th-century *Diccionario Motul* are in fact unattested. It is therefore possible that Classical Yucatec prohibited (homorganic) */T'…T/ in roots no less than */T…T'/. A symmetric co-occurrence restriction of the same kind is also observed in **Chol** (Gallagher 2008, Gallagher & Coon 2009), where co-occurring homorganic plosives must be completely identical—that is, either both pulmonic or both ejective (with the possible exception of /k'…k/, of which three examples are reported in Gallagher & Coon 2009).

Finally, **Old Georgian** might be added to the list of languages displaying place- and voicing-dependent 'airstream harmony' of a similar kind. The segmental inventory of Old Georgian contained three series of plosives: voiced (/d/), voiceless aspirated (/t^h/) and ejective (/t'/). MacEachern (1999) notes that homorganic stops from the latter two classes did not co-occur in roots. (This is apparently no longer true in Modern Georgian). In other words, stops which agree in place of articulation as well as in voicing must also agree with respect to the pulmonic vs. glottalic distinction (in effect, they must be completely identical). However, the fact that the pulmonic voiceless stops are phonetically aspirated might suggest that laryngeal

[75] According to Dayley (1985), /ɓ, ɗ/ are realized as ejective [p', t'] in coda position. Note further that the pulmonic voiced stops [b, d, g] do occur as well in Tzutujil, but only in relatively recent borrowings from Spanish.

harmony in Old Georgian specifically targeted homorganic stops carrying incompatible laryngeal specifications: [+spread glottis] vs. [+constricted glottis].

Harmony requirements to that effect are attested elsewhere, for example in Aymara, whose plosive inventory contains ejectives, aspirates and plain voiceless stops. Aymara prohibits the root-internal co-occurrence of ejectives and aspirates, but dialects differ in the scope of this restriction (MacEachern 1999). With only a handful of exceptions, the dialect that MacEachern labels **'Peruvian' Aymara** (represented by the dictionaries of Ayala Loayza 1988 and Deza Galindo 1989) does not allow any root-internal co-occurrences of ejectives and aspirates, regardless of whether the plosives are homorganic or heterorganic. In the dialect MacEachern refers to as **'Bolivian' Aymara** (de Lucca 1987), on the other hand, the corresponding harmony requirement is more limited, in that it is parasitic on place. In Bolivian Aymara, heterorganic sequences like /t'…p^h/ or /p^h…k'/ are allowed, while homorganic ones like */t'…t^h/, */p^h…p'/, etc., are ruled out Although the Bolivian dialect does allow heterorganic ejective-aspirate combinations, these are subject to certain ordering restrictions: if the first plosive is coronal or dorsal, the order must be ejective…aspirated (see MacEachern 1999 for discussion).

In addition, both Aymaran varieties appear to disfavor the co-occurrence of plain voiceless stops with either ejectives or aspirates at the same place of articulation. In other words, homorganic sequences of the type /T'…T/, /T…T'/, /T^h…T/ and /T…T^h/ are extremely rare (MacEachern 1999). Thus, in addition to prohibiting the co-occurrence of otherwise-identical pulmonic vs. glottalic stops—as in Hausa, Yucatec, and Chol—Aymara similarly bans aspirated and unaspirated plosives of the same place of articulation from co-occurring. This kind of place-dependent 'aspiration harmony' is attested elsewhere, for example in the Indo-Aryan language **Gojri** (Gujari), whose plosive inventory comprises voiced (/d/), voiceless unaspirated (/t/) and voiceless aspirated stops (/t^h/). Based on a search of Sharma (1979), MacEachern (1999) concludes that in Gojri, homorganic voiceless stops differing in aspiration are not allowed to co-occur within a morpheme (only three exceptions were found). Homorganic voiceless stops that agree in aspiration are allowed (/c^hɪc^hɭəp/ 'cobra', /pəʈpəʈo/ 'blunt'), as are homorganic pairs of an aspirated and unaspirated stop, as long as these differ in voicing (/bap^həɳ/ 'eyelash'), but sequences like */t^h…t/ or */k…k^h/ are not attested. The Gojri co-occurrence restriction can be analyzed as a root-internal aspiration harmony which is parasitic on identity in both place of articulation and voicing.

As we saw with the cases from Ijoid languages (Kalabari Ijo, Bumo Izon), root-internal laryngeal harmony need not be dependent on identity in place of articulation. The Ethiopian Semitic language **Chaha** (Leslau 1979, Banksira 2000, Rose & Walker 2004, Rose & King 2007) displays a three-way laryngeal harmony, involving [±voice] as well as [±constricted glottis], which holds between heterorganic and homorganic stops alike. In fact, due to the severe OCP[Place] restrictions characteristic of all Semitic languages, co-occurring stops are almost always heterorganic. The examples in (63a) show that in triconsonantal roots, harmony holds not only between root-adjacent stop pairs like C_1 vs. C_2 but also non-root-adjacent C_1 vs. C_3 pairs. With respect to voiced (pulmonic) and (voiceless) ejective stops, comparison with related languages reveals that the harmony has been enforced by means of regressive assimilation (Banksira 2000); this is illustrated in (63b).

(63) Chaha: regressive laryngeal harmony in roots (Rose & Walker 2004)

a. Examples of harmonic roots

jɨ-dəg(ɨ)s	'he gives a feast'	(D…D)
jɨ-dərg	'he hits, fights'	(D…D)
jɨ-kətf	'he hashes (meat)'	(T…T)
jɨ-kəft	'he opens'	(T…T)
jɨ-t'ək'ɨr	'he hides'	(T'…T')
jɨ-t'əβk'	'it is tight'	(T'…T')

b. Comparative evidence for regressive harmony (Rose & Walker 2000)

Chaha	*Amharic*		
t'ɨk'ək'	dɨk'ək'	'be crushed/ground!'	(D…T' > T'…T')
wɨt'ək'	wɨdək'	'snatch!'	(D…T' > T'…T')
gɨda	k'ɨda	'draw liquid!'	(T'…D > D…D)
mɨdad	mɨt'ad	'griddle!'	(T'…D > D…D)

Fricatives are exempt from the harmony (Rose & Walker 2004): they neither harmonize with stops ([sɨgd] 'worship!') nor amongst themselves ([wɨzf] 'procrastinate!'). More interestingly, laryngeal harmony does not affect labial stops, for which no laryngeal contrasts exist. Voiced [b] does occur, but only as an allophone of /β/, which Banksira 2000 analyzes as a sonorant ([jɨ-zəβk'] 'he daubs' vs. [zəbək'-əm] 'he daubed'); ejective [p'] is found only in a handful of borrowings from Amharic. Apparent exceptions to laryngeal harmony also arise from a morphologically conditioned process of devoicing (reflecting earlier gemination) which can affect stops in penultimate root position (cf. [jɨ-gədɨr] 'he puts to sleep' vs. [gətər-əm] 'he put to sleep'). For this reason, Rose & Walker (2004:496, n. 19) suggest that voiceless pulmonic stops may not act as triggers for laryngeal harmony in Chaha.

The data in (63b) show that harmony between voiced pulmonic and voiceless ejective stops is an innovation in Chaha. According to Rose & King (2007), this co-occurrence restriction is exceptionless for C_1-C_2 pairs, very strong for C_2-C_3 pairs (with an Observed/Expected ratio of 0.32), and weaker but significant (O/E = 0.70) for C_1-C_3 pairs. The situation is more complex for the co-occurrence of voiceless pulmonic stops with voiced stops on the one hand (pure voicing harmony) and with ejectives on the other (pure 'airstream harmony'). With respect to the former, the effect is quite weak. While voiceless-voiced co-occurrences (/D…T/ or /T…D/) are categorically absent for C_2-C_3 pairs, they do occur in C_1-C_2 pairs with a frequency indistinguishable from chance (O/E = 0.96), and are in fact strongly *over*represented for C_1-C_3 pairs.

By contrast, the co-occurrence restriction on voiceless pulmonic and ejective stops (*/T…T'/, */T'…T/) is categorical in Chaha. Moreover, comparative evidence from Amharic suggests that this aspect of the laryngeal harmony may represent a generalization of a weaker (gradient) restriction on root-adjacent stops that Chaha had inherited from an earlier historical stage. Thus a gradient [±constricted glottis] harmony is found in **Amharic** roots as well (Rose & King 2007), where /T…T'/ or /T'…T/ combinations are strongly underrepresented for C_1-C_2 and C_2-C_3 pairs (with Observed/Expected ratios of 0.33 and 0.25, respectively); no significant effect is present for C_1-C_3 pairs.

An interesting three-way laryngeal harmony, which shows signs of being place-dependent despite also targeting heterorganic stop pairs, is found in the Nguni subgroup of Bantu languages, the chief members of which are Zulu (Isizulu), Xhosa (Isixhosa), Ndebele and Swati (Siswati). For example, Khumalo (1987) notes the existence in **Zulu** of a laryngeal consonant harmony governing the morpheme-internal co-occurrence of (non-click) stops: 'they will either all be [+aspirated] or all will be [+depressed] or all will be unspecified'. The stops Khumalo analyzes as [+depressed] are fully voiced stops (/b/, /d/, etc.), whereas the phonetic realization of the segments he treats as laryngeally unspecified stops (/p/, /t/, etc.) seems to vary between ejectives and voiced fricatives, depending on their position in the word. The laryngeal harmony pattern is illustrated in (64).

(64) Zulu: root-internal laryngeal harmony (Khumalo 1987)

a. Well-formed verb stems with multiple stops

ukú-pet-a	'to dig up'	(T…T)
úku-táp-a	'to collect (honey, etc.)'	(T…T)
ukú-k^het^h-a	'to choose'	(T^h…T^h)
úku-p^hát^h-a	'to hold'	(T^h…T^h)
ukú-gub-a	'to dig'	(D…D)

b. Disallowed morpheme-internal combinations

*p…t^h *p^h…t *p…d *b…t *p^h…d *b…t^h (etc.)

c. Laryngeal harmony in loans from English

í-k^hôt^ho	'court'	(T^h…T^h)
úm-bídi	'conductor' (< Eng. *beat*)	(D…D)

Khumalo (1987) finds no counterexamples to laryngeal harmony among regular disyllabic roots in Zulu. The phonological reality of the harmony is also supported by data, as in (64c), where English word-final /t/ is rendered as aspirated or voiced depending on the laryngeal features of the initial stop; see also (66b) below.

As noted above, the 'voiceless unaspirated' series of Zulu, shown above as /p, t, k/ and represented with 'p, t, k' in the orthography, are in fact realized as ejective in some positions, and as voiced fricatives (at least in the case of /k/) in other positions. In his description of the closely related **Ndebele**, which displays the same laryngeal harmony pattern (65), Sibanda (2004) distinguishes between these realizations. In Ndebele, no genuinely voiceless unaspirated stops ([p, t, k]) occur at the phonetic level; orthographic 'p, t' (/p, t/) are consistently ejective [p', t'], whereas 'k' (/k/) can be realized either as ejective [k'] or as the voiced fricative [ɣ]. The latter two are in complementary distribution: in general, ejective [k'] (along with [p', t']) is confined to root-initial position, otherwise [ɣ] is found. The ejectives [p', t', k'] also occur root-internally when prenasalized (e.g. [-namp'uk-a] 'to be sticky'); note that prenasalized stops (as well as clicks) do not participate in the laryngeal harmony ([-t^hint'-a] 'to touch', [-k^hoŋk'ot^h-a] 'to bark'). Otherwise, root-internal ejectives can only occur root-internally when preceded by a C_1 ejective, as in (65c). (The velar [k'] can only be preceded by another [k']; see below.). Interestingly, the harmony appears to have once categorized implosives and ejectives together (on the basis of their [+constricted glottis] specification). In Ndebele, the implosive /ɓ/ that is found in other languages of the Nguni group has changed into a voiced fricative /β/. The fact that it still licenses the occurrence of an ejective stop in C_2 position, as seen in (65d), is a relic of this earlier state of affairs.

(65) Ndebele: root-internal laryngeal harmony for non-prenasalized stops (Sibanda 2004)

a. Co-occurring voiced stops (D…D)

-badal-a	'to pay wages, money'
-dob-a	'to pick up'
-gug-a	'to age'

b. Co-occurring voiceless aspirated stops (T^h… T^h)

-p^hap^h-a	'to fly'
-t^hap^h-a	'to take out (honey from a nest, clay from a pit)'
-k^hup^h-a	'to remove'

c. Co-occurring ejective stops ([T'… T'] = /T…T/)

-t'op'ol-a	'to peck, prick with beak'
-t'ot'-a	'to sink down in wet or muddy place'
-p'at'ul-a	'to slap lightly'

d. Disharmonic roots due to recent /ɓ/ > /β/ change (ɓ…T' > β…T')

-βot'oɣ-a	'be soft when felt with fingers'
-βot'oz-a	'to palpate, feel gently with fingers'

Sibanda further notes that exceptions to the harmony often have a historical explanation, such as in (65d) and in [-dep^h-a] 'to be deep' (< /-de-p^h-a/ with a denominal/deadjectival suffix /-p^h-/; Khumalo 1987:31), and that they show a strong tendency to be harmonized. For example, he notes that the two (related) verbs /-k^hudumal-a/ 'to become warm' and /-k^hudumez-a/ 'to warm up' are pronounced by most people as [-gudumala] and [-gudumeza], respectively.

One quirk of the segmental phonology of Zulu interferes with the laryngeal harmony, namely the general requirement that the aspirated velar stop /k^h/ is restricted to root-initial position (Khumalo 1987). In other positions, only /k/ occurs (= [k'] ~ [ɣ]). Based on a search of Pelling (1971), Hyman (1999a) finds that the same restriction holds in Ndebele as well (see also Sibanda 2004).[76] The complex interplay between this ban against non-initial [k^h] and the laryngeal harmony is illustrated for Ndebele in (66). In those morphemes where a non-C_1 velar would be expected to be an aspirated /k^h/ due to laryngeal harmony, /k/ (realized as a fricative [ɣ]) appears instead. Interestingly, /k^h/ is able to occur in this position if the stop with which it is harmonizing is also a velar /k^h/ (66b)—in which case /k/ ([ɣ]) is *not* a possibility.

(66) Ndebele: non-initial velars and laryngeal harmony (Pelling 1971; cf. Sibanda 2004)

a. Heterorganic stops: prohibition against non-C_1 [k^h] overrides harmony

-p^hek-a	(= [-p^heɣa])	‘cook, brew’	(no */p^h…k^h/ allowed in roots)
-p^hik-a	(= [-p^hiɣa])	‘argue, deny’	
-t^huk-a	(= [-t^huɣa])	‘abuse, curse’	(no */t^h…k^h/ allowed in roots)
-t^hikaz-a	(= [-t^hiɣaza])	‘be disturbed’	

b. Homorganic stops: harmony overrides prohibition against non-C_1 [k^h]

-k^hok^h-a	‘pull, draw out’	(no */k^h…k/ = [k^h…ɣ] allowed)
-k^huk^h-ul-a	‘sweep away’	

Empirically speaking, the interaction between the constraint against non-root-initial /k^h/ and laryngeal harmony is quite robust; Sibanda (2004) reports no exceptions to it at all in verb roots. In a search of C-initial verb stems in a computerized version of Pelling (1971), Hyman (1999a) finds only 9 examples where C_2 = /k^h/, all but one of which have a /k^hVk^h…/ shape.[77] Loanwords also seem to follow the same pattern (e.g. Zulu /-k^hek^he/ < Eng. *cake*).

The pattern in (66) can be accounted for if Ndebele and Zulu are understood to be subject to two separate laryngeal harmony requirements which stand in a stringency (subset) relation: a general constraint against the co-occurrence of laryngeally distinct stops, and a constraint against the co-occurrence of laryngeally distinct *homorganic* stops. Note that the latter has clear parallels in many of the languages discussed earlier in this section. If each of these har-

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76 Strictly speaking, the restriction on /k^h/ in Ndebele (and probably Zulu as well) needs to refer not to root-initial position but to the *first consonant* in the root, as /k^h/ is found in VC roots (/-ak^h-a/ ‘build’, /-ok^h-a/ ‘roast’). This may suggest that initial onsetless syllables are not parsed into prosodic domains (Downing 1998). The Ndebele (and Zulu) restriction might then be that [k^h] must be initial in the Prosodic Root (cf. Inkelas 1990, Inkelas & Zoll 2005).

77 The sole exception is /-zok^hel-a/ ‘provoke’, which Hyman speculates might have reflexive structure (/zi-ok^hel-a/). Note also that postnasal deaspiration (and ejective realization) renders the laryngeal harmony opaque in nouns like [iŋ-k’ok^hel-o] ‘wages’ (from /-k^hok^hel-a/ ‘to pay wages’). Finally, some apparent examples of /k^h/ in non-C_1 position in nouns involve a double prefixation structure; thus /ubu-luk^huni/ ‘stiffness, hardness’ is really /ubu-lu-k^huni/ with /k^h/ = C_1. These factors account for all of the apparent exceptions to the generalization that /k^h/ in non-C_1 position in the root is always due to harmony with a preceding /k^h/.

mony requirements is formalized as a ranked and violable constraint, the disharmonic forms in (66a) can be blamed on a markedness constraint against (non-initial) [k^h], which outranks the general version of laryngeal harmony but is itself outranked by the place-dependent version of the harmony. Using somewhat informal constraint labels, the ranking relation would be $\text{LARHARM}_{[\alpha\text{PLACE}]}$ >> *[k^h] >> LARHARM. This type of interaction, as well as other kinds of similarity effects, are dealt with more extensively in chapters 4 and 5 (see §5.1.3 in particular).

Voiced /g/ in Ndebele patterns in ways very similar to /k^h/ with respect to the harmony in (66); according to Sibanda (2004), so does the [k'] realization of /k/. Wherever laryngeal harmony predicts /d…g/ and /b…g/, we instead find disharmonic /d…k/ and /b…k/, with laryngeally unspecified /k/ (= [ɣ]) instead of the voiced /g/ (/-dak-w-a/ 'be drunk', /-dik-is-a/ 'palpitate, twitch'). This is analogous to (66a), where /k/ = [ɣ] appears instead of expected /k^h/. When the root-initial stop is itself velar, /g/ reappears due to harmony, just as /k^h/ does in (65b) (e.g. /-gug-a/ 'wear out'). Likewise, when C_1 is [k'] (= /k/), a velar in C_2 position must be /k/, and is furthermore realized as ejective [k'] rather than the [ɣ] otherwise typical of non-initial position (e.g. [-k'ak'-a] *no gloss*, [-k'ik'izela] 'cry out joyfully (as women at a dance)'; both from Sibanda 2004:163).

Interestingly, while /k^h/ is clearly disfavored in non-C_1 position (as is [k'], along with the other ejectives [p', t']), it is not quite clear that the same is true for voiced /g/. Though Sibanda (2004) does not report any occurrences of /g/ in C_2 position outside of /gVg…/ contexts, examples do occur in Pelling (1971), such as /-fug-a/ 'push a cart', /-lag-is-a/ 'send cattle to grazing place', /-hug-a/ 'allure, entice'. If there is no phonotactic constraint which militates against root-internal /g/ in Ndebele and Zulu, it is not immediately obvious what the motivation is for disharmony in forms like /-dik-is-a/ [-diɣisa] (↛ *[digisa]). One possible explanation might be some kind of surface analogy with the pattern displayed by /k^h/ in (66) (and ejective [k'] as well).This might perhaps suggest, in turn, that voicing harmony is historically a secondary development—that is, a generalization of what was originally an aspiration harmony to an all-purpose laryngeal harmony (Hansson 2004a). A proper explanatory account of this intriguing case will have to await further research.

The disharmonic root-internal velars (/k/) in cases like (66a) are also interesting from the point of view of locality: the transparency vs. opacity of intervening 'neutral' segments. Even though these velars are phonetically continuants ([ɣ]) rather than stops, they do at some level belong to the class of consonants over which the laryngeal harmony is defined (since sequences like *[k^h…ɣ], *[k'…ɣ], *[g…ɣ] are all prohibited). The failure of the C_2 velars in (66a) to undergo harmony is therefore different in kind from the 'neutrality' of intervening vowels and sonorants (or, for that matter, of intervening non-coronals in a coronal harmony system). Rather, it is due to blocking by a higher-ranked constraint, the demands of which happen to conflict with those of laryngeal harmony. Evidence from loanword adaptation in Zulu, shown in (67), suggests that an intervening /k/ is *transparent*, allowing (heterorganic) stops on either side to harmonize with each other in aspiration and voicing (Khumalo 1987). The forms in (67a), repeated from (64c), show that the rendering of English word-final /t/ is governed by laryngeal harmony with a preceding stop. In (67b), where a medial velar stop intervenes between the final /t/ and an initial (labial) stop in the English source word, the Zulu reflex of English /t/ harmonizes with the initial stop, not with the intervening /k/ (which is presumably realized as [ɣ] here; see above).

(67) Zulu: transparency of medial /k/ in loanwords (Khumalo 1987)

a.	í-k^hôt^ho		'court'	(T^h…T^h)
	úm-bídi		'conductor' (< Eng. *beat*)	(D…D)
b.	iː-p^hákét^he	(= [p^h…ɣ…t^h]?)	'packet'	(T^h…k…T^h)
	iː-bakêde	(= [b…ɣ…d]?)	'bucket'	(D…k…D)

The forms in (67b) indicate that the C_1-C_3 harmony interaction holds across the C_2 /k/. Note that C_1 and C_3 happen to be heterorganic in these examples; the preference for C_3 to harmonize with C_1, rather than with C_2, can therefore not be blamed on the stronger demand for homorganic obstruents to harmonize than for heterorganic ones to do so. (Had the (67b) cases instead been Zulu renderings of English words like *ticket* or *docket*, say, this would have been a straightforward explanation for the transparency of medial /k/.) Nevertheless, it is likely that the transparency of these intervening velars has something to do with the fact that they are (presumably) realized not as stops but as continuants.

To summarize, laryngeal consonant harmony is reasonably well attested in the world's languages. However, its effects rarely extend across morpheme boundaries, and this type of consonant harmony is therefore primarily manifested in the form of static morpheme structure constraints. Also, laryngeal harmony is remarkably often dependent ('parasitic') on identity in place of articulation and/or in other laryngeal features than the one which defines the harmony (e.g. identity in [±voice] in cases of 'airstream harmony'). More often than not, the result of this dependence is the *total* identity of the interacting consonants (on total vs. partial identity in co-occurrence restrictions, see Gallagher 2008, Gallagher & Coon 2009; cf. §2.4.8 and §4.1.2). As for which phonological features can be targeted by laryngeal harmony, it appears that virtually every conceivable type is attested. Voicing harmony is found in Kera, Ngizim, Dime, Ndebele, Zulu and Chaha; Hausa voicing harmony is parasitic on [+constr. glottis] (implosives vs. ejectives); most Berber languages have voicing harmony in sibilants specifically (Tashlhiyt, Tamazight, Tuareg). Aspiration harmony (in voiceless stops) is found in Ndebele and Zulu, and parasitic on [αPlace] in Aymara (Bolivian and Peruvian) and Gojri. 'Airstream harmony' in terms of the [±constricted glottis] feature occurs in Chaha; it is parasitic on [αvoice] in Kalabari Ijo and Bumo Izon, and parasitic on [αPlace] in Hausa, Tzutujil, Modern Yucatec, Aymara (Bolivian and Peruvian), and possibly also Old Georgian. Finally, the co-occurrence of [+spread glottis] and [+constricted glottis] stops (aspirates and ejectives) is specifically prohibited by laryngeal harmony in Peruvian Aymara, and is parasitic on [αPlace] in Bolivian Aymara and possibly in Old Georgian.

2.4.8. Major-Place Consonant Harmony: An Unattested Harmony Type?

Earlier works dealing with consonant harmony phenomena have observed that one type is conspicuously absent from the set of attested long-distance consonant assimilations: harmony in terms of major place of articulation (Shaw 1991, Gafos 1999, Ní Chiosáin & Padgett 1997, Walker 2001, Rose & Walker 2004). That is, we do not find cases of assimilatory interaction where, say, a [dorsal]…[coronal] sequence gets harmonized either to [coronal]…[coronal] or [dorsal]…[dorsal]. True, autosegmental spreading of the [coronal] node is proposed for Sanskrit *n*-retroflexion by Schein & Steriade (1986) and for Tahltan coronal harmony by Shaw (1991). However, in both of these cases the trigger and target segments are required to be coronals (i.e. carry an underlying [coronal] node of their own), such that the result is assimilation in terms of any and all features that are *subordinate* to the [coronal] node ([±anterior], [±distributed], and perhaps [±strident]). These cases do not involve assimilation in 'coronality' as such, as would be the case if [coronal] were to spread to consonants underlyingly specified as [labial] or [dorsal]. Alternative solutions involving the spreading of sub-coronal features (and/or the relevant articulatory gestures) have been proposed for the Sanskrit and Tahltan cases (Blevins 1994, Ní Chiosáin & Padgett 1997, Gafos 1999; cf. also Halle et al. 2000). It thus remains an as-yet-undisputed claim that consonants never assimilate in major place of articulation across an intervening vowel, as in /dVg/ → [gVg] or /bVn/ → [bVm].

The apparent lack of major-place consonant harmony is all the more striking in light of two additional observations. For one thing, long-distance major place *dissimilation* is cross-linguistically well attested (Alderete & Frisch 2007). Many languages display OCP[Place] effects, whereby the co-occurrence of homorganic consonants—in particular ones which agree in other properties, such as sonorancy, voicing and/or stricture—is either strongly disfavored (statistically under represented) or categorically prohibited. The most famous examples are the dissimilatory constraints on the consonantal roots of Semitic languages (Greenberg 1950), such as Arabic (McCarthy 1986, 1988, 1994, Yip 1989, Pierrehumbert 1993, Frisch & Zawaydeh 2001, Frisch et al. 2004) and Ethio-Semitic languages like Amharic and Chaha (Rose & King 2007). Other cases of OCP[Place] effects of a similar kind include English (Berkley 1994, 2000, Dmitrieva & Anttila 2008), Russian (Padgett 1995), French (Berkley 2000), Latin (Berkley 2000), Japanese (Kawahara et al. 2006), Ngbaka (Thomas 1963, Mester 1988b), Ju|'hoansi (Miller-Ockhuizen 2003), Muna (Coetzee & Pater 2008b), Javanese (Uhlenbeck 1949, 1950, Mester 1988b, Yip 1989), Yucatec Maya (Noguchi 2007), Gitksan (Brown 2008, Brown & Hansson 2008), and various creole languages (Kinney 2005). Such effects may even hold across an intervening consonant, as with the C_1-C_3 effects detailed for Arabic by Frisch et al. (2004) and for Muna by Coetzee & Pater (2008b).

Major place dissimilation at a distance may also produce alternations. Long-distance [labial] dissimilation is attested for Akkadian (von Soden 1969, McCarthy 1981, Yip 1988) and for most Berber languages, such as Tashlhiyt (Elmedlaoui 1995a, 1995b) and Tuareg (Heath 2005). In both cases, a prefixal /m/ is realized [n] when the following stem contains a labial consonant (e.g. Tamashek Tuareg [æ-n̲æs-b̲æɣor] 'rich man', [æ-n̲æs-dærf̲ɑ] 'freer of slaves', both with denominal agentive /mæs-/, cf. [æ-mæs-dɑlɑ] 'wearer of green'; Heath 2005). Another example of [labial] dissimilation is Ndebele (Sibanda 2004), where the passive suffix /-w-/ triggers palatalization of a bilabial consonant in the preceding verb stem (e.g. /-limaz-w-a/ → [-liɲazwa] 'be harmed', /-ɬaᵐbulul-w-a/ → [-ɬaᶮdʒulul-w-a] 'be cleansed'). Needless to say, the existence of long-distance major-place dissimilation but not major-place harmony is only a paradox under the *a priori* assumption that harmony and dissimilation are closely related phenomena which ought to exhibit similar typological profiles. The significance of the observed typological mismatch between the two depends on what their relationship is believed to be.

The second and rather more puzzling fact is that the absence of major-place consonant harmony only holds with respect to *adult* language, not child language. In the phonological acquisition process, long-distance assimilations among consonants are a very frequent and well attested phenomenon (Lewis 1936, Menn 1971, Smith 1973, Vihman 1978, Berg 1992, Levelt 1994, Stoel-Gammon & Stemberger 1994, Goad 1997, Bernhardt & Stemberger 1998, Berg & Schade 2000, Rose 2000, Pater & Werle 2001, 2003). In some cases, the assimilations involved closely match the types of consonant harmony that exist in adult language, such as sibilant harmony ([s] vs. [ʃ]), nasal consonant harmony ([l] vs. [n], [b] vs. [m], etc.), even stricture harmony ([s] vs. [t]). The one glaring exception is major place harmony which, though apparently unattested in adult language, is by far the most common type of consonant harmony in child language. Again, the significance of this mismatch depends on what one assumes the relationship to be between the patterns labelled 'consonant harmony' in child and adult language, respectively—whether these are taken to be essentially the same (homologous) or fundamentally distinct phenomena.

The claim that major place harmony does not exist in adult language has been repeated so often in the literature on phonological theory as to almost constitute a truism. However, an examination of the full range of cross-linguistically attested co-occurrence restrictions reveals that this claim may not be categorically true, at least not without qualification. For example, numerous languages display restrictions whereby co-occurring segments of a particular type (e.g. two ejectives, two aspirates, two nasals, etc.) are required to be completely identical. In most cases, this effectively means that the two segments are required to agree in *place of articulation*. After all, two non-identical ejective stops are by definition identical in all respects *except* place, and the same is true of heterorganic pairs of (voiceless) aspirated stops, full nasals, and so on.[78] One conceivable formulation of these types of co-occurrence restrictions is that they constitute 'parasitic' place harmony: harmony that is dependent on identity in certain other features, such as [constricted glottis] or [nasal]. As such, this phenomenon

[78] This may require a definition of 'homorganic' and 'place of articulation' that is somewhat stricter than is customary. For example, in a language with subsidiary contrasts among coronals (or dorsals), such as between alveolar and retroflex stops (/tʰ/ vs. /ʈʰ/), these are non-identical without being 'homorganic' in the conventional sense—in that both have the same *major* place of articulation.

would be no more remarkable than other kinds of parasitic consonant harmony, such as voicing harmony in Ngbaka (dependent on [αPlace]) or Ngizim (dependent on [–constr. glottis]), stricture harmony in Yabem (dependent on [αPlace]), coronal harmony in Kalasha (dependent on [αstrident, βcontinuant]), and so forth.

Most cases that might be examples of such parasitic place harmony involve segments that agree in some marked *laryngeal* feature. Many of the languages discussed in MacEachern (1999) and §2.4.7 above have root-internal co-occurrence restrictions than could be characterized in this manner. In **Gojri**, for example, co-occurring (voiceless) aspirated plosives must be identical. The same is true for **Peruvian Aymara**, where, in addition, co-occurring ejective plosives are likewise required to be identical. The same ban against pairs of non-identical ejectives holds in **Bolivian Aymara** (which lacks the restriction on aspirates), as well as in **Tzutujil** (Dayley 1985) and numerous other Mayan languages, such as **Tzotzil** (Weathers 1947), **Chontal** (Keller 1959), **Chol** (Gallagher 2008, Gallagher & Coon 2009), and Classical and Modern **Yucatec** (Straight 1976, Lombardi 1990, Noguchi 2007). This pervasive Mayan pattern is illustrated for Chol in (68). Note that /ts'/ and /tʃ'/ are independently prevented from co-occurring by sibilant harmony (§2.4.1.1). As for the inability of ejective /tʲ'/ to co-occur with either of the ejective affricates /ts', tʃ'/, this might be attributable to the kind of stricture harmony described in §2.4.6, whereby coronal fricatives and affricates (obstruents differing only in stricture) are not allowed to co-occur in Chol roots.

(68) Chol: major-place harmony among ejectives? (Gallagher & Coon 2009)

a. Roots with homorganic (identical) ejectives

p'ip'	'wild'
tʲ'otʲ'	'snail'
ts'aʰts'	'soak'
tʃ'ɨtʃ'	'absorb'
k'ok'	'healthy'

b. Heterorganic (non-identical) ejectives do not co-occur

*p'…tʲ', *p'…ts', *p'…tʃ', *p'…k'
*tʲ'…p', *tʲ'…k'
*k'…p', *k'…tʲ', *k'…ts', *k'…tʃ'

Finally, **Hausa** requires any co-occurring glottalic consonants to be identical. Since the Hausa inventory contains both ejectives and implosives, this means that glottalic consonants are required to agree in both voicing and place: homorganic ejective-implosive pairs are not allowed, but neither are heterorganic combinations of two ejectives or of two implosives.

Potential examples of place harmony that is parasitic on non-laryngeal features are rarer and more suspect. Root-internally in **Ganda** (and possibly already in **Proto-Bantu**), co-occurring nasals are required to be identical—that is, homorganic (Katamba & Hyman 1991). Thus /-mVm-/ or /-nVn-/ are permissible roots in Ganda, but not /-mVn-/ or /-nVm-/. The palatal nasal /ɲ/ appears to be exempt from this, as it may co-occur with both /m/ and /n/.[79] A similar restriction holds in **Pohnpeian**, where alveolar (or dental) /n/ vs. velar /ŋ/ are one of the segment pairs that 'are almost never found within the same morpheme' (Rehg & Sohl 1981:46). As mentioned in §2.4.3 above, /ŋ/ is likely velarized [ŋˠ], judging by the coarticulatory effects it has on neighboring vowels, and the co-occurrence restriction may be more appropriately viewed as secondary-articulation harmony. As in Ganda, the Pohnpeian co-occurrence restriction does not hold over all places of articulation: the labial nasals /m/ and /mˠ/ freely co-occur with /n/ and /ŋ(ˠ)/ alike (/nim/ 'drink', /mɔŋe-/ 'head', /mˠɛŋɛ/ 'eat').

As noted earlier, all of the potential example of major-place harmony are such that the interacting consonant types are required to agree in *all* features—that is, they must be totally identical. It is quite possible that this is significant, and that a more appropriate characterization would be a separate category of 'total' consonant harmony (rather than major-place harmony as such). If so, how should the phenomenon be analyzed? In earlier works on autosegmental phonology (McCarthy 1989, Yip 1989), cases like the Mayan ones, where ejectives may co-occur only when identical, were dealt with by the same mechanisms as other long-distance consonantal assimilations (e.g. coronal harmony), namely in terms of the spreading/sharing of feature-geometric nodes. For 'total harmony', the node in question is the Root node—which, in the Mayan case, may be shared by C_1 and C_2 in a C_1VC_2 morpheme. Such autosegmental root-node spreading across an intervening vowel presupposes V/C planar segregation, if association lines are not to be crossed. Indeed, co-occurrence restrictions such as those found in Mayan languages were adduced as evidence that V/C planar segregation is not dependent on consonants and vowels belonging to separate morphemes (McCarthy 1989).

Other examples that would superficially fit the 'total harmony' category include Javanese, Muna, and Semitic languages such as Arabic. In the Semitic case, so-called 'geminate' or biliteral roots (where $C_2 = C_3$, as in Arabic /samam/ 'to poison') defy the otherwise general OCP[Place] restriction that root-adjacent consonants must not be homorganic (Greenberg 1950, McCarthy 1981, 1986). In Javanese roots, where a similar OCP[Place] restriction holds, total identity is allowed between C_1 and C_2 (e.g. /babot/ 'carpet'; Uhlenbeck 1949, 1950, Mester 1988b, Yip 1989). In the autosegmental tradition, both cases were analyzed as involving root-node sharing/spreading across an intervening vowel (presupposing V/C planar segregation). Gafos (1998, 1999) argues that the notion of long-distance consonantal spreading (that is, spreading or sharing of a root node across an intervening vowel)—and, by extension, V/C planar segregation as well—should be abandoned. Gafos instead reduces the consonant-identity effects found in Semitic 'geminate' roots to *correspondence*, more specifically Base-Reduplicant correspondence (see §4.1.3 below). This is rendered possible by proposing that the vocalic morphemes in Semitic are in fact reduplicative affixes—thus triggering the presence of a Base-Reduplicant correspondence relation within the output form—whereas the

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[79] This is a slight oversimplification of Katamba & Hyman's (1991) findings for Ganda: /n/ and /ɲ/ co-occur only in the order /nVɲ/, as */ɲVn/ roots are unattested. Order plays no role in the co-occurrence of /m/ and /ɲ/: both /mVɲ/ and /ɲVm/ roots exist.

presence of a stem-final C 'slot' is enforced by independent phonotactic and prosodic constraints. In a stem such as [$s_1am_2am_3$] 'poison', [m_3] is thus *not* part of the root /s_1m_2/ (and hence does not violate the OCP[Place] constraint on root consonants), but rather to the reduplicative affix /a_{RED}/. Finally, the fact that the reduplicant affix is a *suffix* (i.e. right-aligned) accounts for the fact that stems in which $C_1 = C_2$ do not exist (*[sasam]), as these would inevitably violate OCP[Place].

Gafos (1998) does not extend this analysis to the similar facts obtaining in languages like Javanese. Here the edge effects are the opposite ($C_1 = C_2$ is allowed in CVCVC roots, but not $C_2 = C_3$), and it does seem likely that this is somehow connected to the fact that prefixing reduplication is rampant in the language.[80] As for the total-identity restriction on ejectives in Mayan languages (or the other putative cases of major-place harmony considered above), however, an analysis in terms of *reduplicative* correspondence is hardly appropriate. Unlike in Semitic, there is no superimposed affixal morpheme present which could be analyzed as a reduplicative affix, which would trigger a Base-Reduplicant correspondence relation. Moreover, the typical state of affairs in these languages is that total identity is only required if the co-occurring consonants agree in some specific (marked) property. For example, in Bolivian Aymara, co-occurring [+constricted glottis] plosives (i.e. ejectives) must be totally identical, whereas the same is not true for pairs of [+spread glottis] plosives, or of plain ([–constricted glottis, –spread glottis]) ones.

For Gafos (1998, 1999), the ulterior motive for eliminating long-distance root-node spreading is more general, namely a version of the Strict Locality hypothesis (§1.2.3), which asserts that spreading never 'skips' intervening segments (Archangeli & Pulleyblank 1994, Flemming 1995, Ní Chiosáin & Padgett 1997, 2001, Walker 2000b, Padgett 2002). Since Gafos (1999) assumes that consonant harmony interactions do involve *spreading*, it becomes all the more important to 'explain away' alleged cases of root-node spreading such as the Semitic one. The alternative approach that is defended here puts matters into a very different perspective, by taking consonant harmony (including coronal harmony) to be due to constraints that call for featural agreement between segments of a particular class, rather than demands for strictly-local spreading of features (i.e. temporal extension of articulatory gestures). As long as 'total harmony' interactions are likewise a matter of agreement rather than spreading, the Strict Locality hypothesis (including the Articulatory Locality version advocated by Gafos 1999) is not contradicted at all. Moreover, the formal analysis of consonant harmony presented in chapters 4 and 5 (following Walker 2000b, 2000c, 2001; cf. Rose & Walker 2004) does indeed appeal to the notion of *correspondence*, but one which is distinct from Base-Reduplicant relations.

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[80] If an analysis in the spirit of Gafos (1998) turns out to be feasible for Javanese as well, this invites the possibility of treating liquid harmony in closely related Sundanese (see §2.4.5 above) as a matter of Base-Reduplicant correspondence between the root-initial consonant and a reduplicative infix. An analysis of precisely this kind is proposed by Suzuki (1999); see §4.1.3 and §4.3.3 for discussion.

As mentioned earlier, Gafos' analysis of total-identity effects as (covert) Base-Reduplicant correspondence is not very suitable for many potential cases of 'total harmony' (or major-place harmony). The move to analyze all consonant harmony interactions as due to (non-reduplicative) segment-to-segment correspondence relations provides an alternative way to deal with such cases without resorting to non-local spreading or gapped phonological representations. MacEachern's (1999) analysis of co-occurrence restrictions involving total identity (e.g. in Tzutujil, where ejectives must be identical) is very much in the same spirit. As discussed in §4.1.2 below, MacEachern proposes a constraint BEIDENTICAL which, in effect, enforces complete identity between the relevant segments.[81] Through rather ingenious use of logical conjunctions and disjunctions of constraints, involving OCP constraints as well as *IDENTITY (the converse of BEIDENTICAL), MacEachern is able to make BEIDENTICAL irrelevant *except* when the two segments agree in the specific property on which the 'total harmony' is parasitic, such as [+constricted glottis].

Though a constraint like BEIDENTICAL is too narrowly defined to be applicable to most cases of consonant harmony—ones that require agreement in some feature [F], rather than complete identity—something akin to it may well turn out to be the appropriate tool for analyzing patterns of 'total harmony'. Gallagher (2008) and Gallagher & Coon (2009) have recently made a very similar proposal for co-occurrence restrictions of this kind. Adopting a model similar to the correspondence-based framework that is used in chapters 4 and 5 below (Walker 2000a, 2000c, 2001, Rose & Walker 2004, Hansson 2007a), Gallagher & Coon propose that the 'total harmony' effects seen in Chol (and other similar cases) is driven by a constraint IDENTITY. This requires complete identity between certain pairs of co-occurring consonants—specifically, those which stand in a 'linking' relation (by virtue of sharing a specified set of features). In a similar vein, Pater (2007) proposes constraints like PLACE-ALL ('If a sequence of consonants has the same specification for place, then it has the same specification for all features') to capture the fact that total-identity pairs are allowed in Muna despite the strong OCP[Place] restrictions in that language (Coetzee & Pater 2008b).

The question remains whether the root co-occurrence restrictions in Mayan languages, Hausa, Aymara, Gojri, Ganda and others like them should be regarded as examples of consonant *place* harmony (agreement in [Place]), or whether 'total harmony' (an all-or-nothing demand for complete identity) is a more appropriate interpretation. Though it is true that all of the relevant cases do involve total identity, the same is true of many individual examples of other subtypes of consonant harmony, such as liquid harmony (Bukusu, Atsugewi). Almost all attested cases of laryngeal harmony—especially those involving [spread glottis] or [constricted glottis]—lead to total identity. However, the existence of laryngeal consonant harmony systems that do not (e.g. Kalabari Ijo, Chaha and, more subtly, Imdlawn Tashlhiyt)

[81] Interestingly, MacEachern (1999:93) suggests in passing that this constraint may lie behind 'segment harmony processes in child speech', a phenomenon which is here understood as being directly related to adult-language consonant harmony patterns.

shows that the apparent total-identity effect is a secondary by-product of the fact that laryngeal harmony is in most cases parasitic on place of articulation.[82]

These observations shed a somewhat different light on the dilemma. Different types of consonant harmony appear to differ in how dependent they are on (prior) agreement in certain other features—or, more broadly speaking, on the relative similarity of the potential trigger-target pair. Coronal harmony appears to be not only the most commonly occurring type, but also the least restrictive in this sense, though examples of 'parasitic' coronal harmony certainly do exist, Kalasha being a particularly striking example (Arsenault & Kochetov 2008, 2009; §2.4.1.1); a more subtle example is Nkore-Kiga (see §5.3.3 below). Laryngeal harmony is less frequent, less likely to extend beyond the confines of the root, and also far more dependent on the interacting consonants agreeing in place, manner, and so forth. Stricture harmony appears to be even more restrictive, but its sheer rarity makes it hard to conclude much about that harmony type. Finally, major-place harmony appears to be so restrictive that it can only hold between segments that are already identical in all other respects (and typically 'marked' in some way), and is only found root-internally. From this perspective, the contrast between child and adult language is not one of presence vs. absence of major-place harmony, but in its relatively unconstrained vs. highly restrictive character. Whereas place harmony can be non-parasitic in child phonology (e.g. /næp/ → [mæp]), it can only manifest itself in adult language when it is parasitic on manner, voicing, and often features like [+constricted glottis] or [+spread glottis].

2.5. Summary

This chapter has presented an overview of the kinds of consonant harmony effects that are attested in the world's languages, based on the most comprehensive survey to date of such phenomena. Using the working definition of consonant harmony introduced in §1.1 above, it was found that a surprisingly wide range of phonetic-phonological parameters can form the basis of consonant harmony interactions. By far the most common type of consonant harmony involves distinctions between coronal sibilants (fricatives and/or affricates), such as apical vs. laminal, or dental vs. alveolar vs. postalveolar (retroflex and 'palato-alveolar'), or some combination of these. Coronal harmony may also involve plosives (oral stops and nasals), and there are even cases where [+anterior] stops and [–anterior] affricates interact.

Other attested types of consonant harmony include dorsal harmony (the velar vs. uvular distinction), secondary-articulation harmony (where consonants agree in velarization, pharyn-

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[82] All of the cases of laryngeal harmony in MacEachern (1999) involve total identity; in other words, all are parasitic on identity in place of articulation (as well as in [±voice], where relevant). In fact, this is the only reason she is able to analyze laryngeal harmony by means of a BEIDENTICAL constraint in the first place. MacEachern is apparently unaware of the existence of cases like Kalabari Ijo, where agreement in the laryngeal feature in question is enforced without necessarily entailing total identity.

gealization, or palatalization), liquid harmony (laterals vs. rhotics, or glides vs. liquids), nasal consonant harmony, laryngeal harmony, and even stricture harmony (stops vs. fricatives, fricatives vs. affricates). Each of these types was discussed in detail and illustrated with examples drawn from one or more attested cases.

Although it is clear from this survey that consonant harmony can be based on a wide range of phonological parameters, not all types are equally well represented. For example, stricture harmony is exceedingly rare, as is secondary-articulation harmony. Liquid harmony is also surprisingly uncommon, considering how frequently liquids are involved in long-distance *dis*similation (Suzuki 1998, Alderete & Frisch 2007). Nasal consonant harmony is found in a sizable number of languages, but the vast majority of these are closely related members of the Bantu family, and the observed instances of harmony in that group are largely cognate. Laryngeal harmony is quite common root-internally, but very rarely reaches beyond the root to give rise to alternations; where it does, the parameter involved tends to be voicing. By contrast, coronal harmony (and sibilant harmony in particular) frequently creates alternations, but is also often observed as a mere co-occurrence restriction on roots.

The variety of attested consonant harmony types raises the question whether there are any properties that *cannot* form the basis of long-distance consonant assimilations. Major place of articulation is the most obvious candidate (though see §2.4.8). Rose & Walker (2004) suggest that the major classificatory features [±sonorant] and [±continuant] do not enter into assimilatory agreement patterns. The survey in this chapter shows that this is clearly not true for [±continuant], since stricture harmony does exist (see §2.4.6), though it is very rare. It is also unclear how to interpret in featural terms those harmonies that involve a glide /j/ alternating with a liquid (Basaa, Pare) or even with a plosive (Pare). The latter comes close to being a candidate for harmony in [±sonorant] (or even [±consonantal]). A general problem may be that consonants rarely differ *only* in [±sonorant], without also differing in one or more of [±continuant], [±nasal], [±lateral] and so forth.

It remains an issue for future research why certain features are more commonly found to participate in consonant harmony than others, why some tend to be limited to morpheme-internal harmony, and why properties like major place of articulation seem never (or almost never) to be subject to consonant harmony. In this respect it is fruitful to examine the diachronic origins of the synchronic harmony patterns in question, especially for the relatively rarer types. For attempts in this regard, see Hansson (2004a) on voicing harmony, and Hansson (2007c) on secondary-articulation harmony. Some cases may well originate in local coarticulatory effects across (i.e. 'through') an intervening vowel, which have become phonologized as a non-local agreement relation between consonants. This may be the case with many cases of coronal harmony (§2.4.1), and quite possibly also dorsal consonant harmony (§2.4.2); Dolbey & Hansson (1999) argue for a similar origin of nasal consonant harmony in Bantu. Finally, there are cases which appear to have arisen through analogical reanalysis of identity patterns which are due to other effects that have nothing to do with 'harmony' as such (Hansson 2004a, 2004b), or represent harmony interactions of a very different kind (Hansson 2007c). The peculiar glide ~ obstruent alternations of Pare may well be connected to 'cyclic mutation' effects (see §2.4.6), and the lateral ~ glide alternations of Basaa (§2.4.5) may have a similar analogical origin. As mentioned in §1.2.1, some consonant harmonies may have originated in the reanalysis of identity patterns that were due to sound symbolism (see §6.3.3 for details). At present, these hypotheses are largely speculative, but it seems likely that detailed diachronic case studies would be able to shed light on the asymmetries among different subtypes of consonant harmony.

Although the attested types of consonant harmony systems are quite varied in terms of the features involved, and may constitute a heterogeneous set with regard to their diachronic origins, the set of cases that have been surveyed here is remarkably uniform. The following chapter will highlight some overarching generalizations that emerge from the survey, some of which set consonant harmony apart from what is otherwise typical of vowel harmony and vowel-consonant harmony phenomena. What emerges is a highly consistent synchronic-typological profile, which in turn provides the foundation for the generalized formal analysis of consonant harmony that is developed in chapters 4 and 5.

3. TYPOLOGICAL ASYMMETRIES: CONSONANT HARMONY AND OTHER HARMONIES

The preceding chapter surveyed the phonetic-phonological properties of consonants that can form the basis of harmony in the world's languages, and attested cases were classified in terms of the featural dimension involved in the assimilatory interaction. The resulting picture is that of a diverse and seemingly heterogeneous set. In this chapter we will see how, despite this diversity in terms of their featural basis, consonant harmony systems have a typological profile that is strikingly uniform in a number of respects. In the following sections, certain aspects of the consonant harmony systems in the database are examined, and empirical generalizations extracted that are then compared with what is known of other kinds of harmony phenomena, namely vowel harmony and vowel-consonant harmony.

Three main topics are investigated: directionality patterns, segmental opacity effects, and interaction with prosodic structure. With respect to directionality, it is demonstrated that anticipatory (regressive, right-to-left) assimilation is the norm in consonant harmony, and can be regarded as a default. Though perseveratory (progressive, left-to-right) harmony is also attested, it can always be attributed to other motivated factors, such as sensitivity to morphological constituent structure. As for segmental opacity (i.e. blocking) effects, which are extremely common in both vowel harmony and vowel-consonant harmony systems, these are virtually unattested in consonant harmony. Instead, vowels and consonants that intervene between the trigger-target consonant pair are consistently inert and 'transparent', in the sense that they are ignored by the long-distance assimilatory relation and do not interfere with it in any way. Finally, whereas other kinds of harmony interactions are very often sensitive to prosody (e.g., stress, foot structure, etc.), consonant harmony never interacts with prosodic factors. For example, consonant harmony is never affected by stress, syllable weight or segmental length, and is never confined to prosodically-defined domains such as the foot.

The consistent typological profile that emerges from this survey forms an important foundation for the phonological analysis, laid out in chapters 4 and 5, of consonant harmony as a phenomenon that is formally and functionally distinct from other types of harmony. This is particularly true of the generalizations regarding directionality effects and opacity effects (or lack thereof), which follow directly from the formal analysis developed in those later chapters. The absence of any interaction with prosody is also significant, and may shed light on the diachronic sources and synchronic-functional motivations of consonant harmony vis-à-vis those of other kinds of harmony (on which see chapter 6).

The structure of the chapter is as follows. Directionality of assimilation is the focus of §3.1. Against the background of directionality patterns in other kinds of harmony systems (§3.1.1), directionality effects in consonant harmony are examined both across morpheme boundaries (§3.1.2) and morpheme-internally (§3.1.3). The issue of opacity vs. transparency of intervening segmental material is dealt with in §3.2. Various types of segmental opacity effects attested in other kinds of harmony are briefly discussed (§3.2.1); these stand in sharp contrast to the near-absence of such blocking effects in consonant harmony (§3.2.2). A well known case which at first glance appears to be a counterexample to this claim, *n*-retroflexion in Vedic Sanskrit, is discussed in some detail (§3.2.3). Finally, section §3.3 addresses the question of interaction with prosodic structure. A detailed overview of the different types of prosody-sensitivity that are attested in vowel and vowel-consonant harmony systems is given in §3.3.1; such effects of prosody are entirely unattested for consonant harmony. Section §3.3.2 discusses an apparent counterexample to this claim, Yabem obstruent voicing harmony, and dismisses it as being due to tone spreading and tone-voicing interaction rather than to any consonant harmony as such.

3.1. Directionality, Dominance and Stem Control

With respect to directionality, a demand for harmony—the agreement between two consonants in their values for some feature [±F]—can in principle be enforced equally well by means of *perseveratory* (progressive, left-to-right) assimilation as by *anticipatory* (regressive, right-to-left) assimilation. The choice between the two might depend on a variety of factors, or it might need to be stipulated on a case-by-case basis. Even though directionality issues have been discussed in the literature on other harmony systems, such as vowel harmony and nasal harmony, previous studies of consonant harmony as a general phenomenon have not dealt with this topic specifically.

In this section, the types of directionality patterns found in other kinds of harmony systems are briefly discussed (§3.1.1), before the directionality patterns that are attested for consonant harmony systems are examined in detail, both in heteromorphemic contexts (§3.1.2) and tautomorphemically (§3.1.3). A clear generalization that emerges from this survey is that anticipatory (regressive) assimilation is the default for consonant harmony. While perseveratory (progressive) assimilation is attested as well, it can always be attributed to other factors, such that the observed directionality is essentially 'epiphenomenal'. The same is not true for most instances of anticipatory harmony, for which the directionality needs to be stipulated as an integral and inherent property of the assimilatory interaction itself. The default designation of anticipatory assimilation is incorporated directly into the formal analysis developed in chapters 4 and 5. As we shall see in chapter 6, this directionality asymmetry is merely one of several characteristics that links consonant harmony with phonological slips of the tongue (on-line production errors) and speech planning in general.

3.1.1. Directionality Patterns in Other Harmony Systems

Baković (2000), in his study of vowel harmony and its formal analysis in Optimality Theory (OT; Prince & Smolensky 2004 [1993]), puts forward the strong empirical claim that vowel harmony systems can exhibit only two possible directionality patterns: *stem control* and *dominance*. In a harmony system under *stem control*, affix segments yield to (that is, assimilate to) segments in the 'stem', or base of affixation; an alternative label for this type is *cyclic* harmony. In a morphologically complex word form, harmony is enforced over each of successively larger domains—[root], [root+sfx1], [root+sfx1+sfx2], and so forth—with the overall result being a pattern of 'inside-out' directionality. That is, in suffixation contexts harmony will propagate from left to right, whereas in prefixation contexts it will go from right to left. This means that a harmony system governed by stem control does not display any independently stipulated directionality of assimilation. Rather, the observed directionality in any given instance is an entirely epiphenomenal consequence of the morphological constituent structure of the word-form in question. In Baković (2000) this is implemented by ranking (output-output) faithfulness to the base of affixation higher than general input-output faithfulness.

The second directionality pattern Baković (2000) allows for, *dominance*, involves one of the feature values being 'active' (dominant) and the other inactive ('recessive'). For example, in vowel harmonies based on tongue-root advancement or retraction, [+Advanced Tongue Root] ([+ATR]) vowels are often dominant whereas [–ATR] vowels are recessive. Recessive vowels yield to dominant vowels, regardless of their linear order or morphological affiliation. Thus, in a full-blown dominant system where [+F] is dominant, both [–F]…[+F] and [+F]…[–F] sequences will harmonize to [+F]…[+F], irrespective of which segment belongs to the root and which to an affix. In this way, dominant-recessive harmony systems likewise do not require any stipulated reference to a fixed directionality of assimilation. Instead, the observed directionality is a consequence of which of the two segments happens to carry the dominant feature value.[1] The main properties of these two attested types of vowel harmony systems are summarized in (1).

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[1] On this particular point, Baković (2000) makes the further claim that it is always the less marked feature value that acts as the dominant one ('assimilation to the unmarked').

(1) Directionality patterns in vowel harmony (following Baković 2000)

a. Stem control

Affix vowels harmonize with stem vowels, regardless of the feature value involved, yielding 'inside-out' harmony.

Result:

Perseveratory harmony in [[stem]+suffix] contexts
Anticipatory harmony in [prefix+[stem]] contexts

b. Dominance

One feature value is 'dominant', the other 'recessive'. Recessive vowels assimilate to dominant ones, regardless of linear order or constituency relations.

Result (if [+F] is dominant):

Perseveratory harmony in [+F]…[–F] contexts
Anticipatory harmony in [–F]…[+F] contexts

In the dichotomy proposed by Baković (2000), directionality of assimilation is always epiphenomenal. It is thus assumed that vowel harmony systems for which the directionality of assimilation (feature spreading) needs to be stipulated outright do not exist; all apparent cases of uniform directionality are explained away as instances of stem control. Whether this strong empirical claim about vowel harmony systems is borne out by the facts is a question that will not be addressed here. What is important to note in the present context is that, at a purely observational level, vowel harmony may involve anticipatory or perseveratory assimilation, depending on a variety of factors. If anything, perseveratory (progressive) vowel harmony appears to be more common cross-linguistically than anticipatory (regressive) harmony, but this may well be due to stem control combined with the fact that suffixation is more prevalent than prefixation.

In the domain of vowel-consonant harmony—comprising such phenomena as nasalization spreading or pharyngealization spreading—both perseveratory and anticipatory assimilation are attested. In a large number of such cases, the observed directionality cannot be feasibly explained in terms of stem control (and certainly not dominance). The typical state of affairs in such systems is that the property in question spreads leftward and/or rightward until it either reaches the edge of the relevant spreading domain (e.g. the word edge) or encounters an opaque segment which blocks the further propagation of harmony in that direction.

For example, perseveratory nasal harmony is found in a number of Austronesian languages. The harmony triggers are usually full nasals (/m/, /n/), but individual languages differ in which types of intervening consonants are opaque to harmony. The examples in (2) are from the Johore dialect of Malay (Onn 1980 *apud* Walker 2000b). In Johore Malay, nasalization affects vowels, glides and glottals (here transcribed as phonetically nasalized, following Walker 2000b), but liquids and obstruents block the spreading of the [+nasal] feature. The span of nasalization is indicated with underlining, and triggering nasals are in boldface.

(2) Perseveratory nasal harmony in Johore Malay (Onn 1980, Walker 2000b)

mãȷ̃ãŋ	'stalk (palm)'
mãʔ̃ãp	'pardon'
mãkan	'to eat'
pə**ŋ**ãw̃ãsan	'supervision'
pə**n**ə̃**ŋ**ãh̃ãn	'central focus'

In Malay, [+nasal] harmony thus propagates leftward from any nasal stop, regardless of where that nasal is located in the word. The reverse directionality is found in a number of West African languages, such as those of the Kwa group. Examples from the Kolokuma dialect of Izon (a.k.a. Kolokuma Ijo; Williamson 1965, 1987, Walker 2000b) are shown in (3). In this language, harmony is triggered either by a full nasal (as in Malay above) or by a contrastively nasalized vowel. Nasalization spreads to preceding vowels, glides and liquids, but is blocked by obstruents; [n] serves as the nasalized counterpart of [l].

(3) Anticipatory nasal harmony in Kolokuma Izon (Walker 2000b)

w̃ã**ĩ**	'prepare sugarcane'
ȷ̃ãɾ̃**ĩ**	'shake'
sɔ̃ɾ̃**ɔ̃**	'five'
tɔ̃n**ĩ**	'light (a lamp)'
sã**n**lo	'gills'
ʊ̃**m**ba	'breath'

In Walker's (2000b) extensive survey of nasal harmony systems, both directionalities of spreading are well attested. There are also cases where nasalization spreads in both directions from a [+nasal] segment of the relevant kind (e.g. Seneca, Urdu, Cayuvava). In light of the generalizations that will be made about directionality in consonant harmony systems in the following sections, it is worth noting that, if anything, *perseveratory* (progressive, left-to-right) spreading as in (2) appears to be considerably more common than anticipatory (regressive, right-to-left) spreading in the survey of Walker (2000b).

Pharyngealization (or 'emphasis') harmony also typically involves directional spreading of a [+Retracted Tongue Root] ([+RTR]) feature. It is frequently bidirectional, but leftward and rightward spreading may differ in their extent and susceptibility to blocking effects. Only a few cases will be mentioned here; all are Middle Eastern languages discussed by Hoberman (1989).[2] In Palestinian Arabic (on which see also Shahin 2002), [+RTR] spreads both left-

[2] Spreading of [+RTR] is also exists in Interior Salish languages (Bessell 1992, 1997, 1998, Shahin 2002). The individual languages differ in the directionality of spreading, some showing regressive harmony, some progressive harmony, and some both. For example, the east-

ward and rightward from an underlyingly pharyngealized consonant; spreading is blocked by an intervening [iː, j, ʃ]. In Cairene Arabic, rightward spreading is more limited than leftward spreading. The latter is unbounded, affecting any and all preceding segments up to the beginning of the word. Rightward spreading, by contrast, is triggered only by a closed emphatic syllable, and only targets following syllables that contain a low vowel. For example, /Saːhib-ak/ 'your (m.) friend' → [SAH.BAK], but /Saːhib-ik/ 'your (f.) friend' → [SAH.bik] (Hoberman 1989:83; capitalization indicates [+RTR]). In the modern Aramaic dialect of the Jews of Iranian Azerbaijan, emphasis spreading appears to be exclusively left-to-right. In this system, words may be either fully emphatic, fully non-emphatic, or mixed. In the mixed case, all non-emphatic syllables must precede any emphatic syllable. In other words, sequences of the type [–RTR][+RTR] are allowed, whereas *[+RTR][–RTR] sequences are not, suggesting unbounded rightward spreading: a hypothetical input [+RTR][–RTR] sequence would surface as [+RTR][+RTR].

This concludes the brief overview of directionality patterns that are attested for other types of harmony. The notions of stem control and dominance (featural asymmetry) were introduced; these will be of importance in the subsequent discussion. It was shown that whereas the existence of truly directional vowel harmony is somewhat controversial, fixed directionality is indisputably attested for vowel-consonant harmony phenomena. This may take the form of consistent perseveratory assimilation (rightward spreading) or consistent anticipatory assimilation (leftward spreading), or sometimes a combination of both, though even then, the two directionalities may differ slightly in their application.

3.1.2. Stem Control vs. Absolute Directionality in Consonant Harmony

Turning now to directionality patterns in consonant harmony, the first thing to note is that truly dominant-recessive systems do not appear to exist. A system of this type would involve a particular feature value [αF] triggering harmony both leftwards and rightwards, regardless of whether the morpheme 'sponsoring' the [αF] specification is a root or an affix. Segments specified with the recessive value [–αF] would always yield to a nearby dominant [αF] segment. This state of affairs is unattested in consonant harmony, at least in heteromorphemic contexts (for dominance-like patterns in morpheme-internal harmony, see §3.1.3). However, the absence of truly dominant-recessive consonant harmony is less striking once we consider the fact that even among vowel harmony systems, dominance is comparatively rare, and is primarily attested for tongue-root harmony.

The other major directionality type that Baković (2000) recognizes, stem control, is robustly attested in consonant harmony. For example, in suffixation contexts harmony frequently results in a suffix consonant assimilating to a consonant in the preceding stem. The latter may either belong to the root or to another (intervening) suffix; the application of har-

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ernmost languages have a 'faucal harmony' which is an unbounded harmony with strictly right-to-left directionality (see Bessell 1998).

mony is thus 'inside-out'. A case in point is the sibilant harmony found in many Omotic languages, such as Koyra (Hayward 1982). Some representative forms from §2.4.1.1 are repeated in (4). Note that here and in subsequent examples, the root (or stem) is indicated in boldface.

(4) Stem-controlled sibilant harmony in Koyra (Hayward 1982)

a.	/**ʃaj**-(u)s-/	[ʃajʃ-]	'cause to urinate'
	/**goːtʃ**-(u)s-/	[goːtʃuʃ-]	'cause to pull'
	/**ʔordʒ**-(u)s-/	[ʔordʒuʃ-]	'make big, increase'
b.	/**ʔordʒ**-osːo/	[ʔordʒoʃːo]	'he/they got big'
c.	/**dʒaʃ**-(u)s-esːe/	[dʒaʃuʃeʃːe]	'let him/them frighten!'

In the (4a) examples, the /s/ of the causative suffix /-(u)s/ assimilates in [±anterior] to a sibilant in the immediately preceding verb root. The same is true of the /sː/ of the 3SgMasc perfective ending /-osːo/ in (4b). Finally, the example (4c) illustrates the recursive or iterative nature of this 'inside-out' (cyclic) harmony: the causative /-(u)s/ suffix harmonizes with the preceding root /dʒaʃ-/, giving rise to [dʒaʃuʃ-]; this in turn triggers harmony in the following 3SgMasc jussive ending /-esːe/, yielding [dʒaʃuʃeʃːe] as the surface form.[3]

Stem control is also found with prefixing morphology, where prefixes harmonize with the base of affixation (which, again, may be morphologically complex). This is the case in the sibilant harmony and dorsal consonant harmony that occurs in Totonacan languages like Misantla Totonac (MacKay 1999) or Tlachichilco Tepehua (Watters 1988); this is illustrated in (5) with examples of dorsal consonant harmony from Misantla Totonac (repeated from §2.4.2). In this language, harmony applies only to derivational prefixes, not inflectional ones, and the same is true of sibilant harmony as well, according to MacKay (1999). Note that suffixation is involved too; I have not been able to ascertain whether suffixes ever contain the kinds of consonants that are potential targets for the harmony (that is, /k, k'/).

[3] Recall from §2.4.1.1 that sibilant harmony in Koyra (unlike that of some related languages) is strictly transvocalic, and thus does not apply when the trigger and target are separated by an intervening syllable. This entails that the /sː/ of /-esːe/ is harmonizing with the [ʃ] of the preceding causative suffix, *not* directly with the [ʃ] (or the [dʒ]) of the root /dʒaʃ-/.

(5) Stem-controlled dorsal harmony in Misantla Totonac (MacKay 1999)

a. Harmony in derivational prefixes:

/min-ka̰ːk-**paqa̰ʔ**/	[míɴqá̰ːqpaχɛ̰́ʔ]	‘your shoulder’
/ut maka-**ʃqat**/	[ʔṵ́t maqáʃqɛ́t]	‘s/he scratches X (with hand)’
/maka-**ɬuqwan**-la(ɬ)/	[maqaɬɔ́qwaɬ]	‘s/he tired X’

b. No harmony in inflectional prefixes:

/kin-**squ**-jan-ni-la(ɬ)/	[kḭ́sqɔjúniɬ]	‘s/he smokes X for me’
/ik-lak-**tsa̰qa̰**/	[ʔḭ́kláqtsa̰qa̰]	‘I chew X’

In (5a) the root induces harmony on a derivational body-part or valence prefix. The forms in (5b) illustrate how inflectional prefixes such as 1Obj /kin-/ or 1Subj /ik-/ are outside the scope of harmony. In the last example, we see harmony targeting the derivational prefix /lak-/ but not the preceding inflectional prefix /ik-/.

The clearest cases of stem control are those where harmony affects prefixes and suffixes alike, yielding bidirectional harmony ‘outwards’ from the root. An example of this is obstruent voicing harmony in the Chadic language Kera. A few representative examples from §2.4.7 are repeated in (6).

(6) Stem-controlled voicing harmony in Kera (Ebert 1979)

a.	/k-**dàːrə̀**/	[gədàːrə̀]	‘friend’
	/k-**dàjgá**-w/	[gədàjgáw]	‘jugs’
b.	/**dʒàr**-ká/	[dʒàrgá]	‘colorful (fem.)’
c.	/k-**dʒàr**-káŋ/	[gədʒàrgáŋ]	‘colorful (coll.)’
	/k-**dʒìr**-kí/	[gìdʒìrgí]	‘colorful (masc.)’

In (6a), voicing harmony affects the nominal prefix /k-/, whereas in (6b) it reaches the feminine suffix /-ká/. Examples like those in (6c) illustrate the bidirectionality caused by stem control: harmony simultaneously affects the /k-/ prefix and suffixes like /-káŋ/ (collective) and /-kí/ (masculine).

It appears that all cases of perseveratory (progressive, left-to-right) assimilation under consonant harmony can be reduced to stem control—at least as regards the application of harmony in *heteromorphemic* contexts (for morpheme-internal directionality patterns, see §3.1.3 below). The table in (7) lists all languages in the survey that exhibit left-to-right harmony in heteromorphemic contexts. For convenience these are categorized in accordance with the classification in chapter 2.

(7) Consonant harmony systems displaying perseveratory assimilation

Coronal (sibilant) harmony

Aari (Omotic), Koyra (Omotic), Benchnon (Omotic), Zayse (Omotic), Rumsen (Costanoan), Izere (Bantu), ?Wanka Quechua (Quechuan)

Coronal (nonsibilant) harmony

Mayak (Nilotic), ?Päri (Nilotic)

Liquid harmony

Bukusu (Bantu), Sundanese (Austronesian), Basaa (Bantu), Pare (Bantu), ?Mwiini (Bantu)

Nasal consonant harmony

Bemba (Bantu), Lamba (Bantu), Luba (Bantu), Ndonga (Bantu), Tonga (Bantu), Herero (Bantu), Ila (Bantu), Kwanyama (Bantu), Suku (Bantu), Kongo (Bantu), Yaka (Bantu), Mbundu (Bantu), Teke (language cluster; Bantu), Tiene (Bantu)

Laryngeal harmony

Kera (Chadic)

Stricture harmony

?Pare (Bantu)

Some of the cases in (7) involve *infixes* rather than suffixes, where harmony applies progressively from the preceding portion of the stem to the infix. This is the case in Izere sibilant harmony and Sundanese liquid harmony (see §4.3.3 below for detailed discussion of the latter). A third case involving infixation is Tiene nasal consonant harmony, in which infixation alternates with suffixation based on templatic considerations; see §2.4.4). In suffixation contexts, harmony in Tiene applies from root to suffix, just as in the other cases listed in (7) above (e.g. [-sɔn-ɔŋ-ɔ] 'be written' from [-sɔn-ɔ] 'write', with stative suffix /-(V)k/ → [-(ɔ)ŋ]). In infixation, on the other hand, the denasalizing version of harmony applies progressively from infix to stem (e.g. [tó-<u>se</u>-b-ɛ] 'cause to send' from [tóm-a] 'send', with causative /-s(V)-/ triggering /m/ → [b] in the root /tóm-/). This cannot be attributed to stem control, since the directionality is from affix to stem (see §4.3.3 for discussion).[4]

[4] Another possible counterexample is sibilant harmony in Teralfene Flemish (Willem de Reuse, pers. comm.), which applies from left to right in compounds like /kaliʃə/ 'licorice' + /zɑp/ 'juice' to yield [kaˈliʃəʒɑp] 'licorice juice', as well as morpheme-internally ([ʒəˈʒɛp] 'Joseph'). The data currently available to me on this particular case are too limited to allow anything conclusive to be said about it. It is conceivable that we are here dealing with an essentially 'dominant-recessive' system, in which [–anterior] sibilants trigger assimilation to the exclusion of [+anterior] one (in line with the Palatal Bias defined in chapter 6); see the discussion of Bantu nasal consonant harmony in §4.3.3.

Anticipatory consonant harmony, in which assimilation applies in a right-to-left fashion, cannot be reduced to stem control in the same way. True, there are individual systems that display anticipatory assimilations for which stem control is a plausible explanation. The abovementioned sibilant and dorsal consonant harmonies in certain Totonacan languages are a case in point, and voicing harmony in Kera even more so. The consonant harmony found in a number of Athapaskan languages may also fall in this category, though this is less clear (see below).

There is a sizeable number of cases of consonant harmony that exhibit anticipatory directionality which goes *against* the morphological constituent structure. In these cases, suffixes trigger harmony in the preceding base of affixation, whereas prefixes conversely assimilate to their base. Perhaps the most striking example of this is the sibilant harmony found in numerous Chumashan languages, including Ineseño, Barbareño and Ventureño, which were described in §2.4.1.1 above. Some relevant forms from Ineseño are repeated in (8); again, root morphemes are indicated in boldface.[5] The examples in (8a) show sibilants in prefixes (causative /su-/, 3Subj /s-/) assimilating to a following root. In (8b), we see that a prefix also assimilates to a suffix (past-tense /-waʃ/), across the intervening root. Finally, forms like those in (8c) show how suffixes like 3Obj /-us/ and past /-waʃ/ trigger harmony in any and all preceding morphemes, be they other suffixes, root morphemes, or prefixes.

(8) Anticipatory sibilant harmony in Ineseño (Applegate 1972)

a.	/k-su-**ʃojin**/	[kʃuʃojin]	'I darken it'
	/s-**api-tʃ^{h}o**-it/	[ʃapitʃ^{h}olit]	'I have a stroke of good luck'
b.	/ha-s-**xintila**-waʃ/	[haʃxintilawaʃ]	'his former Indian name'
c.	/s-**api-tʃ^{h}o**-us/	[sapits^{h}olus]	'he has a stroke of good luck'
	/s-**api-tʃ^{h}o**-us-waʃ/	[ʃapitʃ^{h}oluʃwaʃ]	'he had a stroke of good luck'
	/s-iʃ-**tiʃi**-jep-us/	[sistisijepus]	'they (2) show him'

It is interesting to contrast Ineseño sibilant harmony against Kera voicing harmony in (6) above. In both cases, prefixes, roots and suffixes are all within the scope of harmony, but while Kera exhibits 'inside-out' harmony (from root to prefixes and suffixes), Ineseño shows a fixed anticipatory directionality that is blind to morphological affiliation or constituency relations.

Another example of absolute right-to-left directionality is the sibilant harmony found in certain Lacustrine Bantu languages, such as Rundi and Rwanda. This is illustrated in (9) for Rwanda.

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[5] Some examples in (8) have a compound stem, consisting of /api/ 'quick' + /tʃ^{h}o/ 'good'.

(9) Anticipatory sibilant harmony in Rwanda (data from Kimenyi 1979)[6]

a.	/ba-ra-**saːz**-je/	[baraʂaːʐe]	‘they are old’
	/a-**sas**-je/	[aʂaʂe]	‘he just made the bed’
	/a-**sokoz**-je/	[aʂokoʐe]	‘he just combed’
b.	/ku-**sas**-iːʂ-a/	[guʂaʂiːʂa]	‘to cause to make the bed’
	/ku-**saːz**-iːʂ-a/	[guʂaːʐiːʂa	‘to cause to get old’
	/ku-**uzuz**-iːʂ-a/	[k-uːʐuʐiːʂa]	‘to cause to fill’

The examples in (9a) show that harmony operates from right to left *within* the root, when a root-final /s, z/ becomes [ʂ, ʐ] by fusion with a following glide /j/ (here of perfective /-je/). Forms like the (9b) ones show that suffixes like causative /-iːʂ/ also trigger harmony in a preceding root, just as in the Ineseño case discussed above.

Related languages occasionally differ in terms of the directionality of harmony, such that one language exhibits stem control and another absolute anticipatory directionality. For example, nasal consonant harmony in Bantu languages is stem-controlled in the vast majority of cases: a suffixal /l/ (or /d/) will harmonize with a nasal in the preceding stem (belonging either to the root or to an intervening suffix). However, there is at least one language in which the effect goes in the opposite direction. In Pangwa (Stirnimann 1983), the nasal of reciprocal /-an/ triggers harmony in a preceding root-final velar /x/, (e.g. /-**pulix**-an-a/ → [-puliŋana] ‘listen to each other’ from /-pulix-/ ‘listen to’).

Aside from clear-cut examples like Ineseño and Rwanda, there is a number of indeterminate cases, in which the observed directionality is always right-to-left, but where all examples of harmony involve prefixing morphology, such that stem control might alternatively be responsible. The consonant harmonies of some Totonacan languages discussed above are an example of this, where stem control is a plausible explanation. Other ambiguous cases include Berber (coronal harmony, voicing harmony), Kera (coronal harmony), Tzeltal (coronal harmony), Tzotzil (coronal harmony) and Yabem (stricture harmony).

The most important group of cases that display anticipatory assimilation in prefixing contexts comprises a number of Athapaskan languages, where consonant harmony of various kinds involving coronal consonants is found (including sibilant *pharyngealization* harmony in Tsilhqot'in, cf. §2.4.3). Most, if not all, consonant harmony systems in Athapaskan are historically cognate with each other, though they show a significant range of variation in terms of their synchronic properties.

With very few exceptions (largely irrelevant for the consonant harmonies in question), Athapaskan morphology is consistently prefixing. This is most striking in the case of verbs, which have an elaborate structure in which the ‘stem’ (≈ root) may be preceded by a long

[6] While the data in (9) are taken from Kimenyi (1979), the transcriptions have been adjusted to take into account the recent finding (Walker & Mpiranya 2005, Walker et al. 2008) that the non-alveolar sibilants (‘š, ž’) of Rwanda are in fact retroflex [ʂ, ʐ].

string of prefixes in an order which frequently goes against the usual 'derivation-inside-inflection' pattern. (See Rice 2000 for a different view of Athapaskan affix ordering, as well as for references to other works on this topic.)

With respect to directionality, the pan-Athapaskan pattern is quite consistent. With hardly any exceptions, harmony is consistently anticipatory: stem segments trigger harmony in prefix segments, and prefix segments in turn trigger harmony in earlier prefixes. Because of the prefixing morphology, it is not straightforward to determine if this anticipatory directionality is absolute (as in Ineseño or Rwanda), or whether it is merely a result of stem control. Enclitics are never affected by harmony, but this may well be due to an independent domain restriction; importantly, enclitics do not trigger harmony either (see Sapir & Hoijer 1967:16). There are independent reasons to believe that Athapaskan consonant harmony is confined to a particular morphosyntactically defined domain, in that elements in the so-called 'disjunct' (i.e. outer) domain are often not affected, unlike prefixes in the 'conjunct' (inner) domain.

Athapaskan consonant harmony is illustrated in (10) with data from Tsuut'ina (Sarcee; Cook 1979, 1984). In this language, a [–anterior] sibilant (/ʃ, ʒ, tʃ, tʃ', dʒ/) triggers harmony in a preceding [+anterior] sibilant (/s, z, ts, ts', dz/).[7] In the (10a) examples, the harmony trigger is a consonant in the stem. In (10b), the triggering [ʃ] results from the fusion of the valence prefix /s-/ with the stem-initial glide /j/.

(10) Sibilant harmony in Sarcee (data from Cook 1979, 1984)

a.	/si-**tʃiz**-aʔ/	[ʃítʃídzàʔ]	'my duck'
	/si-**tʃogo**/	[ʃìtʃógò]	'my flank'
	/na-s-**ɣatʃ**/	[nāʃɣátʃ]	'I killed them again'
b.	/sa#ts'i-gu-si-ni-s-**jáj**/	[ʃátʃ'ìgùʃìʃáj]	'you forgot me'

The first two examples in (10a) are possessed forms of nouns, where the 1SgPoss prefix /si-/ surfaces as [ʃi-] under the influence of a [tʃ] in the following noun stem. In the third (10a) example, the 1SgSubj marker /s-/ similarly harmonizes with the following verb stem. In (10b) example, the incorporated postpositional phrase /sá-/, the deictic subject marker /ts'i-/ and the perfective marker /si-/ all undergo harmony. In all cases in (10), the anticipatory directionality could either be taken at face value (as absolute) or attributed to stem control.

The same directionality pattern obtains in the other Athapaskan languages in the survey, such as Chiricahua Apache, Plains Apache (Kiowa Apache), Tsilhqot'in (Chilcotin), Tahltan, Dane-zaa (Beaver), Dene-tha (Slave) and Tanana. In the best known example of consonant harmony in Athapaskan, that of Navajo sibilant harmony, there are certain wrinkles in the general pattern that may shed light on the nature of the directionality in Athapaskan consonant harmony more generally.

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[7] Certain instances of the glide /j/ also trigger harmony; see Cook (1978, 1979) for discussion.

In most cases, Navajo sibilant harmony follows the same basic pattern as in the Tsuut'ina examples in (10). As illustrated in (11), stem sibilants trigger harmony in prefix sibilants, and prefix sibilants in turn trigger harmony in prefix sibilants earlier in the word. As before, the 'stem' (≈ root) is indicated in boldface.

(11) Anticipatory sibilant harmony in Navajo (data from McDonough 1991)

a.	/dʒ-i-z-**dá**/	[dzizdá]	'he sat down'
	/dz-iʃ-ɬ-**haːl**/	[dʒiʃhaːl]	'I tumble into the water' (imperf.)
b.	/si-**dʒéːʔ**/	[ʃidʒéːʔ]	'they (slender stiff objects) lie'
	/dz-iʃ-ɬ-**ts'in**/	[dzists'in]	'I hit him below [the belt]'

In (11a), a later prefix (perfective /(i)z-/, 1SgSubj /(i)ʃ-/) triggers harmony in an earlier prefix (so-called '4th person' /dʒ-/, adverbial /dz-/ 'away from'). In (11b), the triggering sibilant is in the stem, affecting any and all preceding prefix sibilants.

However, it has been noted (Kari 1976, Young & Morgan 1992, McDonough 1991) that there also exist cases where harmony systematically applies *progressively* within the prefix string in Navajo. The first of these involves the interaction between the conjugation (or 'mode') marker /s(i)-/ with an immediately following subject prefix. The /s(i)-/ marker characterizes paradigms which are typically perfective (the so-called 's-perfective', in Athapaskanist terminology), but it also occurs in imperfective paradigms based on certain verb stems. Synchronically speaking, the conjugation marker may no longer be a separate morpheme in its own right. For example, McDonough's (1990, 1991) analysis of the Navajo verb treats the combination of a conjugation/mode prefix with a following (1st or 2nd person) subject marker as an indivisible unit, the Inflectional Stem. While this analysis may be appropriate synchronically, the 'Inflectional Stem' historically consisted of two separate morphemes. The facts presented below should be understood in this light.

The combinations of the /s(i)-/ prefix with subject prefixes in perfective paradigms in Navajo are shown in (12), drawing on Faltz (1998). The parenthetic morpheme boundary indicates the separation between conjugation marker and subject prefix (if any); as noted above, this boundary may be more of a historical fact rather than a synchronic reality. In any case, the precise location of this boundary should be taken with a grain of salt (and is not important in this context).[8]

[8] To be precise, the prefix shapes in (12) are the ones that are used specifically with verb stems that carry a /d-/ or /l-/ 'classifier' (valence prefix). The paradigm used for stems with no classifier, or a /ɬ-/ classifier, differs slightly from that in (12), but this is irrelevant here.

(12) Navajo: subject prefix paradigm for 's-perfectives' (Faltz 1998:74)

	Singular	*Plural*
1st	**s(-)is-**	s(-)iːd-
2nd	sí(-)ní-	s-oːh
3rd	s-(Ø-)	s-(Ø-)

What is notable about the prefix paradigm in (12) is the 1Sg prefix combination. In other contexts, the 1SgSubj marker contains /ʃ/ (as does the 1Sg possessive prefix on nouns); this was evident from some of the examples in (11). It thus appears that in the combination of the conjugation marker /s(i)-/ with the 1SgSubj prefix /(i)ʃ-/, the resulting string /s-iʃ-/ undergoes perseveratory assimilation to [sis-] rather than the expected anticipatory harmony (*[ʃiʃ-]).

Interestingly, this 'reversed' directionality is found only in those cases where the /s(i)-/ prefix defines a *perfective* paradigm. In the *imperfective* paradigms that make use of this prefix (these are relatively few in number), harmony applies in the expected direction, as shown in (13).

(13) Navajo: subject prefix paradigm for 's-imperfectives' (Faltz 1998:383)

	Singular	*Plural*
1st	**ʃ(-)iʃ-**	s(-)iːd-
2nd	s(-)í-	s-oh
3rd	s-(Ø-)	s-(Ø-)

In the paradigm in (13), it is the 1SgSubj prefix /(i)ʃ-/ that triggers harmony on the preceding conjugation marker /s(i)-/, exactly opposite to what we saw in the perfective paradigm in (12).

McDonough (1990, 1991) analyzes the prefix combinations in (12)–(13) as indivisible wholes, alternate (suppletive) realizations of an inflectional stem rather than combinations of a distinct conjugation/mode prefix with a subject prefix. This inflectional stem is treated as a single morph with no internal structure, which entails that the sibilant harmony observed in the 1Sg slot in (12) and (13) is equivalent to *morpheme-internal* consonant harmony. On this account, the difference between the two 1SgSubj morphs /sis-/ (perfective) and /ʃiʃ-/ (imperfective) is synchronically arbitrary—equivalent, say, to the difference between two distinct lexical items that happen to contain /s/ and /ʃ/, respectively. The diachronic observation that the difference in phonological shape of these two elements is due to different directionalities of sibilant harmony is lost in this synchronic analysis.

The same is not true of the other prefix that is known to trigger progressive harmony in Navajo. Incidentally, this prefix also has the shape /s(i)-/, and is used in verbs of killing (with a singular object). This prefix, referred to as the 's-destruct' by McDonough (1991), occurs in roughly the same linear position in the prefix string as the conjugation marker /s(i)-/ discussed earlier.[9] Just like that prefix, the 's-destruct' morpheme is typically followed directly by the subject agreement prefix. When it is followed by the 1SgSubj prefix /(i)ʃ-/, as in (14), progressive assimilation results.

(14) Navajo: perseveratory harmony with 's-destruct' prefix (McDonough 1991)
/s-iʃ-ɬ-**jé**/ [sisxé] 'I'm killing it (imperf.)'
/s-iʃ-**dlí**/ [sisdlí] 'I froze to death (perf.)'

In the s-perfective and s-destruct cases alike, the underlying /ʃ/ of the 1SgSubj prefix harmonizes with an /s/ in an immediately preceding prefix. In McDonough's (1991) analysis, the s-destruct prefix is a separate morpheme, unlike the s-perfective. Her solution to the unusual directionality is to mark this particular morpheme diacritically as 'reversing the direction of the spread' of [±anterior] values.

Before dealing with the implications of the Navajo facts for the typology of directionality effects in consonant harmony, one more detail is worth noting. Anticipatory harmony emanating from the verb stem/root *overrides* the perseveratory assimilation seen in the s-perfective and s-destruct paradigms, as shown by the s-perfective forms in (15). For the sake of illustration, the input representation presupposes that the conjugation marker /s(i)-/ and 1SgSubj /(i)ʃ-/ are separate prefixes.

(15) Navajo: harmony from root overrides prefix harmony (McDonough 1991)
/s-iʃ-l-**ʒeːʔ**/ [ʃiʃʒeːʔ] (no gloss)

In sum, Navajo does display perseveratory harmony (albeit to a limited degree) from what appears to be an 'outer' prefix to an 'inner' prefix. This seems to contradict the generalization stated earlier in this section, that perseveratory directionality in consonant harmony can always be reduced to stem control. However, things may not be as simple as this. In both the s-perfective and the s-destruct cases, the triggering morpheme is an aspectual or adverbial prefix which defines an entire inflectional (sub)paradigm, with individual slots in that paradigm characterized by particular person/number specifications for the subject (and possibly the object as well). The targeted prefix is a subject agreement marker. Cross-linguistically, affixes of the former type strongly tend to occur *inside* of affixes of the latter type; in this respect, Athapaskan languages are rather unusual in terms of affix ordering.

What is more, Athapaskan verb morphology shows various dependency effects that may be relevant. For example, the choice of perfective paradigm (s-perfective being one of the options) is to a great extent *lexically* determined, varying from verb to verb. Moreover, the

[9] Young & Morgan (1992) interpret this /si-/ prefix as being in 'position VI', along with various adverbial prefixes, rather than in the immediately preceding 'position VII' which hosts the conjugation/mode prefixes. It is unclear whether this is based on any evidence other than the semantics and morphological function of the two.

realization of the subject agreement prefixes can depend on the particular paradigm type involved. For example, 1SgSubj is generally marked with /(i)ʃ-/, but for one class of verbs, the s-perfective paradigm (and certain others as well) uses the alternative allomorph /é-/, yielding /s-é-/ rather than the /s-iʃ-/ (→ [sis-]) shown in (12) above. In other words, allomorph selection for subject prefixes is sometimes dependent on the conjugation marker. By contrast, subject prefixes never condition allomorph selection in conjugation markers.

For reasons such as these, it is far from obvious that the subject prefixes should be considered to be 'inside' the conjugation markers (or aspectual prefixes like the s-destruct) in terms of *constituent* structure, despite what the linear ordering of prefixes might suggest. It seems reasonable to interpret the directionality from conjugation marker to subject agreement prefix in (12) and (14) as being 'inside-out' (cyclic)—and hence an instance of stem control. Interestingly, in the radical reanalysis of Athapaskan verb morphology proposed by Rice (2000), the entire (conjunct) prefix domain is a left-branching structure, [[[[X] Y] Z]…], where earlier prefixes are thus effectively 'inside' later ones. If this analysis is correct—even if only with respect to conjugation/mode markers vs. subject agreement markers—then the left-to-right directionality observed in (12) and (14) is merely a reflection of stem control. On this interpretation, Navajo is not a counterexample to the generalization that perseveratory directionality is always epiphenomenal. This further entails that the prevailing anticipatory assimilations observed elsewhere in Navajo sibilant harmony—as well as in its congeners elsewhere in Athapaskan (e.g. Tsuut'ina/Sarcee in (10))—are not stem-controlled but rather due to *absolute* anticipatory harmony. In this respect, consonant harmony in Athapaskan languages turns out to be much like that of Ineseño or Rwanda in (8) and (9) above.

To sum up, consonant harmony in heteromorphemic contexts appears to display only two fundamental directionality patterns. One is stem control, whereby affixes harmonize with the base to which they attach. This can give rise to right-to-left harmony (onto prefixes) or left-to-right harmony (onto suffixes), or a combination of both ('bidirectional' harmony) in cases where the harmony domain includes prefixes and suffixes alike. The second type is fixed or absolute directionality, which is insensitive to morphological constituency. In those cases, harmony applies in a right-to-left fashion, as *anticipatory* assimilation. There are no instances of absolute directionality involving perseveratory (progressive, left-to-right) assimilation. In this sense, anticipatory directionality stands out as the default for consonant harmony; perseveratory assimilation, when it occurs, is a by-product of the influence of morphological constituent structure. The following section examines directionality patterns in tautomorphemic contexts, where constituent structure is absent.

3.1.3. Directionality Effects and Morpheme-Internal Consonant Harmony

If anticipatory (progressive, right-to-left) assimilation is the default directionality of consonant harmony, as was argued in §3.1.2, then we should expect tautomorphemic contexts—where the confounding factor of stem control is inapplicable—to display *exclusively* anticipatory harmony. As this section will show, that prediction is indeed borne out, though with certain qualifications.

In a large number of languages in the survey, consonant harmony is manifested solely as a morpheme-internal co-occurrence restriction. In most cases of this sort, the harmony is a static distributional pattern over lexical entries (roots), and little can be inferred about any kind of directionality. However, even in such situations it is occasionally possible to see harmony 'in action', as it were. One source of evidence is comparative-historical, where an earlier disharmonic stage is documented or can be reconstructed based on comparison with closely related dialects or languages (or doublet forms within the same dialect). Also, morpheme-internal harmony may be fed by independent phonologically or morphologically induced segmental alternations affecting root consonants.[10]

One case where the directionality is mostly evident from comparative data is sibilant harmony in the Mayan language Ixil (Ayres 1991). Here harmony is only found in the Nebaj dialect, and cognate disharmonic forms in the neighboring Chajul dialect attest to the fact that Nebaj harmony follows anticipatory directionality (16a). Moreover, harmony is to some extent optional even in Nebaj. As a result, harmonic and disharmonic versions of the same words can be compared, as in (16b); these too attest to the anticipatory directionality of Nebaj Ixil sibilant harmony.[11]

(16) Anticipatory sibilant harmony in Ixil (Ayres 1991)

a. Comparative evidence (Nebaj vs. Chajul dialects)

Nebaj	*Chajul*	
tʃitʃam	ʈʂitʃam	'coach, car'
tʃ'atʃ	ʈʂ'atʃ	'bed'

b. Doublet forms in the Nebaj dialect

tʃ'isis ~ ts'isis	'cypress'
tʃ'eveʂ ~ ʈʂ'eveʂ	'annona, custard apple'
siːn-ʂeʔ ~ ʂiːn-ʂeʔ	'with me'

Another case which clearly shows anticipatory directionality is obstruent voicing harmony in the Chadic language Ngizim (Schuh 1978, 1997), discussed in detail in §2.4.7 above (see also

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[10] This is true not only of systems where harmony is confined to the root domain. For example, in the Rwanda examples in (9a), the fusion of root-final /s, z/ with suffixal /j/, yielding [ʂ, ʐ], is what creates a trigger for anticipatory retroflexion harmony.

[11] Note that the last example in (16b) is morphologically complex; this is the only such form cited by Ayres (1991), who does not mention whether Nebaj Ixil harmony applies regularly across morpheme boundaries. Since it is unclear to me whether the relational morpheme /-ʂeʔ/ should be analyzed as a stem or a suffix (or clitic), I hesitate to categorize this case as an example of either stem control or fixed anticipatory directionality.

§4.2.3 below) and illustrated in (17). In Ngizim, directionality is evident from comparison with cognates in related languages, as in (17a), from which it is evident that [+voice] obstruents triggered anticipatory assimilation. The directionality also leaves its mark in the form of an asymmetry in the synchronic distributional pattern. Since [–voice] did not trigger harmony, and since the [+voice] harmony was strictly anticipatory, the end result is that only sequences of the *[–voice]…[+voice] type are ruled out, whereas [+voice]…[–voice] sequences are allowed.

(17) Anticipatory voicing harmony in Ngizim (Schuh 1997)

a. Harmonic roots (/T…T/, /D…D/):

kùtə́r	'tail'	
tàsáu	'find'	
gâazá	'chicken'	(< **k…z*; cf. Hausa /kàazáa/)
də́bâ	'woven tray'	(< **t…b*; cf. Hausa /tàafii/ 'palm')
zədù	'six'	(< **s…d*; cf. Hausa /ʃídà/)

b. Disharmonic roots (/D…T/ allowed, but not */T…D/):

bàkú	'roast'
gùmtʃí	'chin'
dùkʃí	'heavy' (Schuh 1978: 251)
zùktú	'pierce' (Schuh 1978:273)

Perhaps the most interesting evidence for the default status of anticipatory directionality comes from systems that exhibit stem-controlled *perseveratory* harmony in heteromorphemic contexts, but *anticipatory* harmony morpheme-internally. The only clear-cut case of this type appears to be the sibilant harmony found in Omotic languages (cf. the Koyra examples in (4) above). Since root-internal sibilant harmony is reconstructed as having obtained already in Proto-Omotic (Hayward 1988), the only evidence bearing on the directionality of harmony in morpheme-internal contexts involves loanword adaptation. In Zayse, borrowings from Amharic typically substitute /ts'/ for Amharic /t'/. In cases where this /ts'/ would be disharmonic with a following sibilant, the affricate assimilates to that sibilant (Hayward 1988). Thus Amharic /t'ädʒː/ 'mead' becomes /tʃ'adʒːe/ in Zayse (rather than */ts'adʒːe/), and Amharic /t'ɨloʃ/ 'brideprice' is borrowed as /tʃ'iloːʃa/ (not */ts'iloːʃa/).

Just as Zayse sibilant harmony is 'fed' by disharmonic borrowings into the language, independent historical sound changes may also feed a pre-existing consonant harmony. One example is sibilant harmony in Wanka Quechua (Cerrón-Palomino 1977), which is manifested solely as a static morpheme-internal co-occurrence restriction. In the Huaicha dialect, the interaction of two sound changes would have been expected to yield some instances of disharmonic morphemes. These historical changes are *tʃ > ʈʂ (other than before [i]) on the one hand, and *ʎ > tʃ (except word-initially) on the other. When a root contained an original sequence *tʃ…ʎ, these regular sound changes ought to produce disharmonic ʈʂ…tʃ. Instead, this disharmony has been ‘repaired’ by applying *anticipatory* harmony, as illustrated in (18). (For expository purposes, I have assumed that the historical development passed through a disharmonic stage, followed by subsequent ‘repair’ by harmonization; it is also conceivable that harmony instead shaped the outcome of the sound changes directly.)

(18) Anticipatory sibilant harmony in Wanka Quechua (Cerrón-Palomino 1977)

Reconstructed		*Disharmonic*		*Actual*	
*tʃukʎa	>	*ʈʂuktʃa	>	tʃuktʃa	‘hut’
*tʃuʔʎu	>	*ʈʂuʔtʃu	>	tʃuʔtʃu	‘corn’
*tʃuʎu-	>	*ʈʂutʃu-	>	tʃutʃu-	‘to melt’
*tʃukʎuʃ	>	*ʈʂuktʃuʃ	>	tʃuktʃuʃ	‘cricket’

Alternatively, root-internal harmony may be fed by a morphologically driven alternation of some kind. This is the case in most of those Western Nilotic languages that display coronal harmony involving dental vs. alveolar stops, and sometimes nasals as well (§2.4.1.2). In these languages, systematic root-final consonant ‘mutations’ may lead to a potentially disharmonic root-internal coronal pair. For example, root-final /l/ (which is redundantly alveolar, and neutral to harmony) changes to alveolar [t] or [nd] in certain forms. In roots of the shape /d̪…l/ or /t̪…l/, this would be expected to yield disharmonic [d̪…t], [t̪…nd], and so forth, other things being equal.

Different languages resolve this in different ways. Shilluk (Gilley 1992) appears to opt for anticipatory harmony. Thus the root /t̪al/ ‘to cook (trans.)’ is realized in the as [ta̲ːt] in the antipassive, and as [tā̲ːd-ā] in the instrumental (instead of otherwise expected [t̪a̲ːt], [t̪ā̲ːd-ā]; underlining indicates [+ATR]). The closely related Päri (Andersen 1988), on the other hand, applies *perseveratory* harmony in such cases, as witnessed by examples like [t̪úon̪d̪-à] ‘my snake’ from /t̪ùol/ ‘snake’ (rather than expected [t̪úond-à]). In this case it is the root-initial dental [t̪] that triggers harmony in the derived alveolar [nd], rather than the other way around.

A plausible explanation for the perseveratory assimilation in Päri has to do with the historical origin of the root-final consonant mutations. For example, the alveolar [-t] in antipassives was clearly once a separate suffix morpheme (Hall & Hall 1996), and the same was likely true of the [-nd] (etc.) that may appear in certain other morphosyntactic contexts. The directionality observed in Päri may be a remnant of *stem control*, whereby these former suffixes assimilated to the preceding root. Note that stem control is attested for coronal harmony in the related Mayak (Andersen 1999), where suffixes like singulative /-it̪/ harmonize (optionally) with an alveolar stop in the preceding root (/dɪːn-ɛt̪/ → [ɗɪːn-ɛt] ‘bird’). Because of this possibility, Päri was included as a questionable case in the table in (7) above, where systems with perseveratory harmony in *hetero*morphemic contexts were listed. Adopting a slightly different perspective, we may also note that in Päri, the realization of a derived segment is affected by harmony. If stem control is a matter of special faithfulness to the base of affixation, as will be assumed in the analysis in chapters 4 and 5, then that subsumes cases of this sort. In a form like [t̪úon̪d̪-à] 'my snake', the dentality of the initial [t̪] is ensured by faithfulness to the related (output) form [t̪úol] 'snake', whereas the alveolarity of the derived [nd] (~ [n̪d̪]) receives no such protection. In this way, the observed perseveratory assimilation in Päri may be a by-product of stem control.

A somewhat similar case, to which the same reasoning can be applied, is dorsal consonant harmony in Tlachichilco Tepehua (Watters 1988). As discussed in §2.4.2 above, this phenomenon interacts with an independent process of coda dorsalization. Coronal or labial stops and nasals are not allowed in coda position, and when parsed into that position, they become velar (/p/ undergoes 'fission' to [wk]): /ʃap-ʔa/ 'X pants (impf.)' → [ʃa.p'a], but /ʃap-ɬi/ 'X panted (perf.)' → [ʃawk.ɬi]). In roots with the shape /q…t/ or /q…p/, coda dorsalization would result in a uvular…velar sequence [q…(w)k], which is prohibited by dorsal consonant harmony. Where this occurs, harmony 'repairs' the sequence by turning the derived velar into a uvular; in other words, the assimilation is perseveratory. An example is /q'ut-ʔa/ 'X drinks it (impf.)' → [ʔo.t'a], but /q'ut-ɬi/ 'X drank it (perf.)' → [ʔoq.ɬi], rather than otherwise expected *[ʔok.ɬi].[12] In this case, just as in the Päri case, the directionality may be due to faithfulness to the underlying uvular taking priority over the derived velar.

Another alternative interpretation is that the perseveratory harmony in Päri and Tlachichilco Tepehua is due to preferential (positional) faithfulness to root-initial consonants (cf. Beckman 1998). If a root-initial consonant is immune to being altered by harmony, the only way to enforce harmony is to assimilate the non-initial consonant(s) to it. This appears to be the case in loanword adaptation in Zulu, where the realization of English word-final /t/ varies according to laryngeal harmony with a root-initial stop (Khumalo 1987; see §2.4.7). Thus, for example, *court* is borrowed as /í-kʰôtʰo/ and *packet* as /iː-pʰáketʰe/, whereas *beat* is borrowed as /úm-bídi/ 'conductor' and *bucket* as /iː-bakêde/.

One case which does appear to display a genuinely problematic directionality pattern is Bantu nasal consonant harmony (§2.4.4). In heteromorphemic contexts, the general left-to-right directionality of this harmony can easily be attributed to stem control, since suffixation is involved. Morpheme-internally, however, the same perseveratory directionality holds as well. Positional faithfulness to a root-initial consonant—in combination with [+nasal] being the active or 'dominant' feature value—goes a long way toward accounting for this pattern. Such an interpretation would explain why root-initial sequences like /m…d…/ turn into [m…n…], whereas initial /b…n…/ remains unaffected. However, such an account predicts that non-initial oral…nasal sequences will undergo *anticipatory* harmony (/C…d…m…/ → [C…n…m]). As pointed out by Rose & Walker (2004:504 n. 30), this is not borne out; counterexamples include Yaka /fólám-/ 'be delighted', /fwéːbám-/ 'be curved (back)' and Kongo

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[12] Note that ejective /q'/ is realized phonetically as [ʔ]; nonetheless it has the same lowering effect on neighboring vowels, and the same harmony effect on nearby /k, k'/, as non-ejective /q/ does. See §2.4.2 and Watters (1988) for arguments for underlying /q'/, and for the debuccalization being a relatively 'late' (postlexical) process. In any case, this complication is not directly relevant here.

/bilum-uk-/ 'assemble in crowd', with unharmonized /…l…m…/ and /…b…m…/. While historically such cases can likely be explained as containing a frozen suffix (/-am/, /-um/), there is no evidence that these strings are morphologically complex from the synchronic perspective. It thus appears that Bantu nasal consonant harmony remains as an exception to the generalization that consonant harmony is anticipatory by default. The implications of this case for the formal analysis of consonant harmony are discussed in §4.3.3 below.

In any case, the suggestion that morpheme-internal Bantu nasal consonant harmony is dominant-recessive (with [+nasal] the dominant value) receives. As noted in §2.4.4 above, the Proto-Bantu root **bon-* 'see' is realized as /mon-/, by *anticipatory* assimilation, in an area that is virtually coextensive with that of (perseveratory) nasal consonant harmony. Another example from Yaka (Larry M. Hyman, pers. comm.) is the reciprocal formed from the root /lu-/ 'fight (trans.)'. With reciprocal /-an/, we would expect /lu-an-a/ → [lwaːna], but instead we find [nwaːna] 'fight each other'. It would be well worth searching for other sporadic examples of this kind.

There exist other cases that seem to involve bidirectional 'dominant-recessive' harmony to some degree. For example, in colloquial Moroccan Arabic sibilant harmony, comparison with Classical Arabic reveals that the [–anterior] sibilant is typically favored regardless of position (Heath 1987, 2002), as shown in (19) (MA = Colloquial Moroccan Arabic; CA = Classical Arabic).[13]

(19) 'Dominant-recessive' sibilant harmony in Moroccan Arabic (Heath 1987)

	CA	*MA*	
a.	zaːdʒ-	ʒaʒ	'glass'
	zulajdʒ-	ʒlliʒ	'tiles'
	sardʒ-	ʃrʒ	'saddle'
b.	ʃams-	ʃəmʃ	'sun'

Some other Arabic dialects of North Africa appear to have consistently anticipatory sibilant harmony rather than the dominant-recessive pattern in (19). Heath (1987:216 n.5) notes that whereas Classical Arabic /dʒ/ generally undergoes deaffrication in the sequence /dʒ…z/ in Moroccan Arabic (yielding MA /d…z/ or /g…z/), the same is not true in most Algerian and Tunisian dialects. Here /dʒ/ instead becomes /ʒ/ even in this context, resulting in disharmonic /ʒ…z/ sequences (e.g. /ʒăzːarˤ/ 'butcher'). In a number of Tunisian dialects, such sequences are harmonized (/zăzːarˤ/; cf. also /zuz/ 'go past' instead of expected /ʒuz/ from CA /-dʒuːz/). In other words, the 'recessive' [+anterior] triggers anticipatory harmony.

Another case of morpheme-internal harmony with certain dominant-recessive characteristics is sibilant harmony in Basque (Hualde 1991, Trask 1997; see §2.4.1.1 above), which

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[13] It should be noted that the observed dominance of [–anterior] is completely in line with the Palatal Bias effects discussed in chapter 6 below.

involves an apico-alveolar vs. lamino-alveolar contrast. Morpheme-internally, laminals and apicals simply do not co-occur. Directionality effects can be observed when loanwords are adapted, and also when compounds are reanalyzed as single morphemes and thus subjected to sibilant harmony. In such cases, harmony appears to be consistently in favor of the apical. For example, Spanish *francés* 'French' is borrowed as /fran(t)seș/ > /fran(t)ș eș/, with anticipatory assimilation, whereas Spanish *sazón* is found dialectally as */ṣasoi(n)/ > /ṣaṣoi(n)/, with perseveratory harmony (Michelena 1985). However, some dialects appear to display anticipatory directionality even in [apical]…[laminal] sequences: /sasoi/.[14]

To sum up, the default status of anticipatory directionality in consonant harmony manifests itself even in morpheme-internal contexts, where regressive assimilation is the norm. Perseveratory (progressive) harmony is found in a small number of cases, but virtually all of these can be blamed on independent factors (analogous to stem control for heteromorphemic cases). For example, an underlying specification in one consonant may take priority over a derived specification in another, resulting in reversed (perseveratory) directionality. Alternatively, specifications of root-initial consonants may take priority, again resulting in directionality reversal. Finally, there are some cases where harmony seems to have a dominant-recessive character, such that perseveratory directionality emerges in dominant…recessive sequences. With the sole exception of Bantu nasal consonant harmony, all attested cases of perseveratory harmony can be accounted for in one (or more) of these ways; the one directionality that ever requires *stipulation* is thus anticipatory harmony. Moreover, even in cases where perseveratory harmony occurs—for whatever reason—related dialects or languages frequently display the exact same harmony but with the default anticipatory directionality.

In the generalized analysis of consonant harmony laid out in chapters 4 and 5, this anticipatory default is incorporated directly into the formal mechanisms responsible for triggering harmony. As discussed in detail in §4.2.1.2 and §6.1, consonant harmony closely resembles phonological speech errors with respect to the predominance of anticipatory interactions. The implications of this and other such parallels is discussed in more detail in the remaining chapters (see especially chapter 6).

3.2. Locality, Transparency and Blocking

The cross-linguistic typology of consonant harmony systems is remarkably uniform in another respect, the treatment of segmental material intervening between the trigger and target of the assimilatory interaction. In any harmony system, potential target segments can be classified as undergoers vs. non-undergoers (those that fail to assimilate); the latter are often also referred to as *neutral*, in that they do not participate in harmony and are unaffected by it. Non-undergoers may be *transparent*, allowing the harmonizing property to be transmitted or propagate across them while remaining unaffected by that property. Alternatively, they may

[14] The tentative generalizations made here for Basque are based on a very small list of forms, culled from various sources; it is possible that they will not stand up to further scrutiny.

be *opaque*, blocking the further propagation of harmony to potential targets on the other side. An opaque segment often (though by no means always) initiates a new harmonic span for the feature in question.

Locality-related issues such as the opacity vs. transparency of intervening nonundergoers are especially important to consider, if only for the reason that in consonant harmony the trigger and target are often spaced far apart, separated by a long stretch of (apparent) non-undergoers. The strict locality approach to consonant harmony, outlined in §1.2.3, assumes that all segments are potential targets, and that when harmony appears to apply in a long-distance fashion, intervening segments are undergoers, targeted by the spreading feature no less than the distal 'target' segment is. Opacity effects are quite commonplace in vowel harmony systems, as well as in those 'vowel-consonant harmonies' that truly seem to involve the local spreading of features like [+nasal] or [+RTR]. In such systems, particular segment types often function as blockers (opaque non-undergoers). If consonant harmony is due to feature spreading, one would expect to find such effects to be robustly attested in its cross-linguistic typology as well. However, as will be detailed below, segmental opacity effects are virtually unattested for consonant harmony. The vowels and consonants that intervene between the interacting consonants are completely inert to the harmony and do not disrupt the featural 'agreement' between the trigger and target consonants on either side.[15]

Section §3.2.1 gives a brief overview of how segmental opacity is found in vowel harmony and vowel-consonant harmony systems. The (near-)absence of opacity effects in consonant harmony is discussed in §3.2.2. Finally, one particularly well known apparent example of opacity effects in what is often described as a 'consonant harmony', Vedic Sanskrit *n*-retroflexion, is discussed at length in §3.2.3. It is argued that this phenomenon—which does indeed appear to involve (strictly-local) feature spreading—should not be classified as consonant harmony at all, as it exhibits a range of properties that are otherwise unattested in consonant harmony systems in the world's languages.

3.2.1. Opacity Effects in Other Harmony Systems

Generally speaking, segmental opacity is extremely common in harmony systems. It might even be said that for non-undergoers, opaque behavior (blocking) is the norm and transparency the exception. In vowel harmony systems, for example, neutral vowels are frequently

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[15] Recall that the definition of consonant harmony used in this work (see §1.1) includes only those assimilations where intervening segments—and vowels in particular—are not *noticeably* affected (or have not been recorded as being affected) by the assimilating property. This does not make the argument circular; in any harmony system, a non-undergoer (in this sense) will either act as an opaque or a transparent intervener. In vowel harmony and vowel-consonant harmony systems, each is quite common (if anything, opacity seems more common); in consonant harmony systems, on the other hand, opaque behavior is practically unattested.

opaque.[16] In tongue-root vowel harmony, either high vowels (Yoruba; Pulleyblank 1996) or low vowels (Tangale; van der Hulst & van de Weijer 1995) are often neutral and opaque. The same is true of rounding harmony systems, where opaque behavior is attested for high vowels (Oroch; Kaun 1995) as well as for non-high vowels (Turkish; Padgett 2002); occasionally a high rounded vowel is opaque to rounding harmony while a high unrounded vowel is transparent (Buriat; Kaun 1995). In height harmony systems where high and mid vowels interact, low vowels are often opaque (Shona; Beckman 1997). In front/back vowel harmony, non-low front unrounded vowels are sometimes opaque (Eastern Khanty; Kiparsky & Pajusalu 2003); occasionally opaque and transparent vowels coexist in the same system (e.g. in the Southern Seto dialect of Estonian, where /i, e/ are transparent and /o/ opaque; Kiparsky & Pajusalu 2003).

Likewise, particular types of intervening consonants can be opaque to vowel harmony, blocking its propagation from one syllable to the next. Often these are consonants which are already specified for the spreading feature, or which have some property which is incompatible with that feature. For example, palatalized or palatal consonants (liquids and dorsals) are opaque to backness harmony in Turkish (Clements & Sezer 1982); these segments block the rightward spread of [+back] and themselves initiate a new [–back] domain. (Interestingly, the glide /j/ does not block backness harmony in this way; see Levi 2001, 2004.) In some rounding harmony systems, such as in Bashkir, /w/ is opaque, blocking the spread of rounding (as do high rounded vowels; van der Hulst & van de Weijer 1995:529). Similarly, labials like /f/, /b/ or /m/ (but not /w/!) are opaque to rounding harmony in Nawuri (Casali 1995).

In the present context, a somewhat closer analogue to consonant harmony might be those phenomena which have here been referred to as 'vowel-consonant harmony'. These involve the spreading of properties such as nasality ([+nasal]) or pharyngealization ([+RTR]) over a span of segments. More often than not, such spreading is *triggered* by consonants of a particular class, just like consonant harmony, but in this case the harmonic property quite clearly (and perceptibly) affects all segments that lie in its path—vowels as well as consonants.[17] Segmental transparency effects are occasionally encountered, whereby segments of a particu-

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[16] In addition to being unaffected by the harmony, an opaque vowel typically initiates a new harmonic span for the feature in question. However, this is not necessarily the case; an intervening opaque vowel may block the propagation of harmony in [±F] to a distal target vowel without spreading its own [F] value to that vowel (e.g. in Enarve Vepsian; Kiparsky & Pajusalu 2003)

[17] In the so-called faucal harmony found in some Interior Salish languages, Bessell (1998) shows that the harmony, which is triggered by pharyngeal and uvular *consonants*, affects only *vowels*, whereas intervening (non-faucal) consonants appear to be relatively unaffected phonetically. Such cases provide an interesting near-parallel to consonant harmony, but nevertheless the two phenomena are distinct. Consonant harmony is assimilatory interaction between consonants—especially ones that are already highly similar—whereas processes like Interior Salish faucal harmony involve assimilation of vowels to consonants.

lar type are 'skipped', but such cases are relatively rare. More importantly, these always involve an *individual* segment being skipped; the harmonic property spreads up to that segment, and spreading commences again on the other side. In nasal harmony, for example, we may find cases like /nawaka/ → [nãw̃ãkã], where the intervening [k] is obviously not nasalized (see Walker 2000b for detailed discussion). What we typically do not find in systems of this kind is the transparency of entire stretches of intervening material comprising several segments. This stands in sharp contrast to consonant harmony, where truly long-distance interactions (e.g. /ha-s-xintila-waʃ/ → [haʃxintilawaʃ] in Ineseño) are nothing out of the ordinary.

Practically every vowel-consonant harmony system displays segmental opacity effects to some degree. For example, pharyngealization harmony ('emphasis' spreading) is frequently blocked by the high front vowel /i/ or the corresponding palatal glide /j/, and occasionally even by 'palatal' obstruents like /ʃ/ (Palestinian Arabic; Hoberman 1989).[18] In Tsilhqot'in (Chilcotin) pharyngealization spreading, (also known as 'vowel flattening'), front velars and contrastively non-pharyngealized sibilants block rightward and leftward spreading of [+RTR] from a uvular, and rightward (though not leftward) [+RTR] spreading from a pharyngealized sibilant (Krauss 1975, Cook 1983, 1987, 1993, Hansson 2007c).

As for nasal harmony, Walker (2000b) surveys a wealth of such systems and arranges them into a typological hierarchy with regard to the class of opaque segments. In some languages, all buccal (i.e. non-glottal) consonants, including glides, are opaque and block the spread of nasalization (Sundanese, Mixtec). In another set of languages, glides are undergoers, whereas all 'true' consonants block spreading (Acehnese, Capanahua). The next possibility is for liquids to be added to the list of undergoers, with all obstruents being opaque (Kayan, Kolokuma Izon). In yet another set, only obstruent stops are opaque, while fricatives undergo nasalization along with sonorants and vowels (Applecross Gaelic). Finally, stops may be targeted by nasalization as well (Cayuvava, Gokana). Additionally, voiceless obstruents may be opaque in some languages, blocking the propagation of [+nasal] (Bribri, Cabécar). Finally, as pointed out by Walker (2000b), some languages categorize the glottals /ʔ, h/ as obstruents, and these can therefore occasionally be opaque to nasal harmony alongside buccal obstruents (Rejang, Kaiwá, Terena).

Aside from this implicational hierarchy of opaque consonants in nasal harmony systems, certain types of *vowels* occasionally act as blockers. For example, in the Mọ̀bà dialect of Yoruba, mid vowels are never nasalized, and block the leftward spread of nasalization (Ajíbóyè & Pulleyblank 2008). Similarly, in the Applecross dialect of Scottish Gaelic upper-mid vowels are consistently oral and block nasal spreading (Ternes 1973).

In sum, segmental opacity effects are extremely common cross-linguistically in both vowel harmony and vowel-consonant harmony systems. Under the interpretation that the harmony in question is due to feature spreading, such effects are to be expected. A given segment may be incompatible with the spreading property to some extent, either because it

[18] More accurately, only long /iː/ is opaque, whereas short /i/ generally undergoes harmony. According to Shahin (2002), *all* long vowels are opaque in Palestinian Arabic, not just /iː/.

contains some conflicting property (opaque /i, j/ in pharyngealization harmony) or because the segment that would result from spreading (e.g. a nasalized mid vowels) is barred from the surface inventory. Such factors may determine whether or not a particular segment undergoes harmony. If it does not, *blocking*, rather than transparency, seems to be the most common result.

3.2.2. (Non-)Locality and Transparency in Consonant Harmony

Turning now to consonant harmony systems, the generalization that emerges from the cross-linguistic survey is that consonant harmony almost universally ignores any segmental material intervening between trigger and target. With only two known exceptions (see §3.2.2.2 below), segmental opacity effects are entirely unattested in consonant harmony systems. The transmission of the harmonic feature is not blocked by a particular subset of consonants and/or vowels, as so frequently happens with other types of harmony. In this sense, the intervening (neutral, non-undergoer) segments are consistently *transparent* to the harmony.

It is important to note that the construal of consonant harmony as strictly-local spreading, where all intervening segments are treated as undergoers and hence as legitimate *targets* of spreading (Flemming 1995, Gafos 1999 [1996], Ní Chiosáin & Padgett 1997, 2001), does not predict that every individual consonant harmony system ought to display opacity effects. For example, there are many vowel harmony systems that do not. What is surprising is, rather, that segmental opacity is so vanishingly rare as to be effectively absent from the entire typology of attested consonant harmony systems. In this respect the typological profile of consonant harmony with respect to opacity vs. transparency is strikingly uniform, and conspicuously different from that of vowel harmony and vowel-consonant harmony.

If feature spreading (gestural extension) were the primary mechanism for consonant harmony interactions, we would expect to see far more cases in which considerations of segmental markedness and/or articulatory incompatibility lead to the blocking of harmony. This is, after all, an extremely common occurrence for vowel harmony and vowel-consonant harmony phenomena. The near-complete absence of such effects lends strong support to the notion that consonant harmony interactions are instead driven by constraints requiring *agreement* between (potentially) non-adjacent segments, as in the formal analysis of chapters 4 and 5 below.

3.2.2.1. Evidence for Genuine Transparency

The survey in chapter 2 includes several cases in which it is indisputable that the assimilatory interaction between the trigger and target consonants takes place across rather than 'through' intervening segments. One obvious case is the peculiar stricture harmony seen in Yabem (/se-n͡dèŋ/ → [dè.n͡dèŋ], /se-dàgùʔ/ → [té.dà.gùʔ], etc.; see §2.4.6), where the oral closure property ([–continuant]) is clearly not affecting the vowel that separates the /s…d/ or /s…t/ pair. Similarly, in the unbounded nasal consonant harmony of languages like Yaka (§2.4.4), intervening vowels and voiceless obstruents are unambiguously transparent (/mí:tuk-idi/ → [mí:.tu.ki.ni]).[19]

Aside from such obvious cases, there are numerous instances of consonant harmony processes where one might expect segments of a certain type to be opaque, blocking the harmony feature from 'spreading' through them, but where this is contradicted by the facts. Consider, for example, the dorsal consonant harmony found in some Totonacan languages (Misantla Totonac, Tlachichilco Tepehua), in which discontinuous velar…uvular sequences surface as uvular…uvular (/k…q/ → [q…q]); see §2.4.2 above. From an articulatory standpoint, there is potential conflict between the tongue retraction inherent in a uvular [q] and the tongue posture required for high vowels, especially the high front vowel [i] (Gick & Wilson 2006). Indeed, these same languages also display a local process of lowering high vowels /i, u/ when adjacent to a uvular. Thus in Misantla Totonac (MacKay 1999), we find /i, u, uː/ → [ɛ, ɔ, ɔː] in /…Vq…/ and /…qV…/ contexts (long /iː/ often diphthongizes, acquiring a low on- or offglide depending on which side the uvular is on: […iəq…] ~ […ɛːq…] vs. […qɛi…] ~ […qɛː…]). In short, high vowels, and [i] in particular, have properties that conflict with those articulatory gestures that define the 'uvularity' of [q]. If dorsal harmony truly involves *extending* these articulatory gestures through intervening vowels and non-dorsal consonants, we expect that if an /i/ or /u/ were to find itself in the middle a harmony span, it should either block the harmony or show clear signs of being phonetically affected by the spreading gesture(s). In other words, a spreading account predicts that a sequence like /k…i…q/ must either remain unharmonized as [k…i…q] or else surface as [q…e…q] or [q…ɛ…q].

Neither is the case; instead, harmony is enforced across the intervening vowel without affecting its phonetic realization, as seen in the Tlachichilco Tepehua examples in (20), repeated from §2.4.2. In this language, /i, u/ lowers to [e, o] adjacent to a uvular. Each of the forms in (20) contains an underlying high vowel which is sandwiched between a velar target and a uvular trigger, without being adjacent to either. (Note that ejective /q'/ surfaces as debuccalized [ʔ] by a late postlexical process; this has no impact on the workings of dorsal consonant harmony, nor on the local vowel lowering effects; see §2.4.2 for more details.)

(20) Tlachichilco Tepehua: no lowering in dorsal harmony span (Watters 1988)
a. /lak-puːtiq'i-ni-j/ [laqpu̲ː̲teʔenij] 'X recounted it to them'
b. /ʔak-pitiq'i-j/ [ʔaqpi̲teʔej] 'X folds it over'

[19] Clements (2001:118) raises a similar though somewhat more subtle point about intervening coronals in the (root-internal) sibilant harmony of Basque (see §2.4.1.1). Clements points out that in cases like [s̺iɲet̺s̺i] 'believe'—which, incidentally, is a historically harmonized former compound (/sin/ 'truth' + /(h)et̺s̺i/ 'consider')—there cannot possibly be a single apico-anterior gesture or feature bundle extending from one sibilant to the other, as this would render the intervening palatal [ɲ] indistinguishable from [n].

If we ignore the (postlexical) debuccalization of /q'/, (20a) displays /k…u…q'/ → [q…u…q'], with transparent [u] rather than the *[q…o…q'] or *[k…u…q'] predicted by a local-spreading account ([u] being either targeted or opaque, respectively). The (20b) similarly shows /k…i…q'/ surfacing as [q…i…q'] rather than as *[q…e…q'] or *[k…i…q'].

Similar evidence for genuine transparency is found in the Northern Athapaskan language Tsilhqot'in (Chilcotin; Krauss 1975, Latimer 1978, Cook 1983, 1987, 1993, Gafos 1999, Hansson 2007c). As described in §2.4.3 above, alveolar sibilants in Tsilhqot'in contrast in pharyngealization, with 'sharp' ([–RTR]) /s, z, ts, ts', dz/ vs. 'flat' ([+RTR]) /sˤ, zˤ, tsˤ, ts'ˤ, dzˤ/. Consonant harmony operates over precisely this distinction, making it a rare instance of secondary-articulation harmony, despite being historically cognate with coronal (sibilant) harmony systems in related languages (see §2.4.3 and Hansson 2007c for arguments against considering Tsilhqot'in a coronal harmony system in the usual sense). In Tsilhqot'in, all alveolar sibilants in a word agree in [±RTR], with the rightmost one determining their surface [RTR] value. The third sibilant series, lamino-postalveolar /ʃ, ʒ, tʃ, tʃ', dʒ/, do not participate in the harmony or interfere with it in any way. Tsilhqot'in also has a velar vs. uvular contrast (/k/ vs. /q/, etc.), which also appears to involve [±RTR] (Cook 1993), given that uvulars and 'flat' sibilants have the exact same lowering and/or retraction effect on neighboring vowels (/æ/ → [ɑ], /u/ → [o], and so forth).

Tsilhqot'in sibilant pharyngealization harmony interacts in a complex way with a synchronically independent process of [+RTR] spreading (Cook 1993, Hansson 2007c).[20] Because of the complexities of this interaction, the independent effect of consonant harmony is best seen in those contexts where the trigger is [–RTR], such that a /Sˤ…S/ sequence surfaces as [S…S] (anticipatory *de*pharyngealization harmony). As noted in §2.4.3, this long-distance assimilation in [–RTR] between two sibilants can take place across a sequence that contains [+RTR] consonants and vowels. The relevant examples (drawn from my own field notes from 2000) are repeated in (21); the word-medial [+RTR] span is enclosed in curly brackets, and the interacting sibilants are in boldface.

(21) Tsilhqot'in: anticipatory [–RTR] harmony across [+RTR] segments

a.	/ɬæ jɛ-tɛ-**sˤ**ɛ-ʁæ-id-jɛ**z**/	[ɬæ jɛtʰɛ**z**{ʌʁɑ}d̥ʒɛ**z**]	
	'we're not going to get the hiccups'		
b.	/ɬæ næ#tɛ-**sˤ**ɛ-ʁæ-id-l-k'ɛ**s**/	[ɬæ nætʰɛ**z**{ʌʁɑ}lk'ɛ**s**]	(speaker A)
	'we're not going to be stiff'	[ɬæ nætʰɛ**z**{ɑ}lk'ɛ**s**]	(speaker B)

In (21) we see long-distance assimilation in [–RTR] in underlying /sˤ…z/ or /sˤ…s/ sequences, where the string of segments that intervenes between the two alveolar sibilants in-

[20] Though these two pharyngealization 'harmonies' are synchronically separate processes, it is likely that they are diachronically connected. Hansson (2007c) suggests that unbounded [+RTR] spreading arose through analogical reanalysis of the combined effects of sibilant pharyngeal harmony and local vowel retraction.

cludes within it a span of [+RTR] material. That span consists of the uvular fricative [ʁ] (of the progressive prefix /ʁɛ-/), as well as the vowels adjacent to it, which are retracted by a local process of [+RTR] assimilation (in the pronunciation of speaker B, the entire /…ɛʁæ…/ sequence is contracted to [ɑ]). These intervening [+RTR] segments do not in any way interfere with the consonant harmony relation that straddles them; they are genuinely transparent.

In harmony systems that display opacity effects, the opaque segment does not necessarily have properties that conflict with the spreading feature. For example, /u/ or labial consonants can be opaque to rounding harmony, and /i/ can be opaque to palatal harmony. Similarly, retroflex stops like /ɖ/ are opaque to retroflexion spreading in Sanskrit (see §3.2.3 below). Again, opacity effects of this kind are not attested in consonant harmony. For example, intervening sonorants (which are phonetically voiced) are never opaque to obstruent voicing harmony. Consider also the fact that laryngeal harmony often presupposes that the trigger and target have matching place and/or manner features. No cases are attested where an intervening non-homorganic or different-manner consonant blocks this kind of laryngeal agreement. Finally, recall that in unbounded nasal consonant harmony systems (Yaka, Kongo), prenasalized stops do not undergo harmony, but also do not block it (see §2.4.4 above).

An especially illustrative example of the failure of intervening segments to act as blockers is the coronal harmony found in many Western Nilotic languages, in particular that of the Northern Burun language Mayak (Andersen 1999; see §2.4.1.2 above). In this language, dental /t̪, d̪/ and alveolar /t, d/ are not allowed to co-occur within morphemes. In Mayak, there is no dental-alveolar contrast in sonorants, such that /n/ is consistently alveolar [n], even when it co-occurs with [t̪, d̪] in the same morpheme.[21] More importantly, in Mayak the coronal harmony extends to suffixes like singulative /-ɛt̪/, /-ʌt̪/ or /-it̪/. When these are affixed to a root containing alveolar /t, d/, they harmonize (optionally), surfacing with alveolar [t] (22a). The alveolar nasal /n/, unlike its oral stop counterparts, does not trigger harmony (22b). However, an alveolar /t, d/ will trigger harmony *across* an intervening [n] (22c). (For simplicity, the optionality of harmony in (22a) and (22c) has been suppressed.)

(22) Mayak: inertness of /n/ to coronal harmony (Andersen 1999)

a.	/tid-ʌt̪/	tiɗʌt	‘doctor’
	/tuɣ-it̪/	tuɣit	‘back of head’
b.	/ʔin-ʌt̪/	ʔinʌt̪	‘intestine’
	/kan-it̪/	kanɪt̪	‘torch’
c.	/diːn-ɛt̪/	ɗɪːnɛt	‘bird’
	/kɛt-ɪn-ɛt̪/	kɛtɪnɛt	‘star’

In a harmony system of this kind, it would have been perfectly conceivable for an intervening /n/ to be opaque, and thus to block the propagation of coronal harmony in the (22c) cases.

[21] Dental [n̪] does occur as an allophone of /n/, but only in the clusters [n̪d̪], [n̪t̪].

This would be entirely analogous to Sanskrit *n*-retroflexion, where non-triggering retroflex consonants are opaque to retroflexion spreading (see §3.2.3 below), or to rounding harmony systems in which /u/ is a non-trigger and also opaque to the spread of rounding. This is not what we find in Mayak, nor in any other consonant harmony system (though see below for discussion of opaque /$^{\text{n}}$ɖ/ in Rwanda sibilant harmony). As we will see in §3.2.2.2, the only two reported examples of segmental opacity effects in consonant harmony systems involve consonants that carry a *conflicting* specification for the feature that is being propagated by harmony.

3.2.2.2. Opaque Segments in Consonant Harmony

At the time of writing of Hansson (2001b), no instances of opacity effects in consonant harmony systems were known to me. The case of long-distance voicing assimilation in Imdlawn Tashlhiyt Berber sibilants (see below) was mentioned briefly in a footnote, but could not be evaluated in detail as the description in Elmedlaoui (1995a [1992]) was not accessible to me at the time. Rose & Walker (2004:480, n. 6) likewise relegate the Imdlawn Tashlhiyt case to a footnote, deeming it to be a fundamentally different phenomenon from the sort of long-distance 'agreement' involved in consonant harmony as defined here. At the time, it thus appeared to be an exceptionless generalization that segmental opacity effects are completely unattested for consonant harmony.

That picture has since changed considerably. Most importantly, subtle opacity effects have been discovered for Rwanda sibilant harmony (Walker & Mpiranya 2005; Mpiranya & Walker 2005). These effects have been corroborated by a detailed articulatory investigation (Walker et al. 2008), which moreover reveals that the long-distance assimilatory interaction between sibilants in Rwanda involves the spreading (extension) of a retroflex tongue-tip posture through intervening vowels and non-coronal consonants. Secondly, further exploration of formal issues relating to the analysis of consonant harmony as correspondence-based agreement (see chapter 4 and Rose & Walker 2004)—and of the nature of the 'spreading' vs. 'agreement' distinction as such—has revealed that opacity effects *can* in fact be generated in an agreement analysis (Hansson 2006a, 2007a, 2007b, Rhodes 2008, Walker 2009b). In particular, local spreading (through intervening segments) can emerge as the optimal strategy for satisfying constraints demanding long-distance agreement, inviting the possibility of opacity effects; this can help explain certain otherwise unexpected aspects of Walker et al.'s (2008) articulatory findings (Hansson 2007b). Finally, a reconsideration of the curious sibilant alternations in Imdlawn Tashlhiyt, and of their cognates in the Southern Berber (Tuareg) branch of the family, suggests that this phenomenon should indeed be categorized as an instance of consonant harmony (long-distance 'agreement' between sibilants). This makes Imdlawn Tashlhiyt a second example of consonant harmony being disrupted by opaque segments.

This section will briefly present the relevant facts of Rwanda and Imdlawn Tashlhiyt. Curiously, both involve sibilant fricatives assimilating to each other. It is worth noting that in both cases, the opaque segments are consonants which carry a value for the harmony feature that is *opposite* to the one that is being 'spread' from trigger to target (though see below for Rwanda /ɳ͡ɖ/).

In the Bantu language Rwanda (Kinyarwanda), as described in §2.4.1.1 above, there is anticipatory sibilant harmony involving the fricative series which are rendered by Kimenyi (1979) as /s, z, n͡z/ vs. /š, ž, n͡ž/. Recent studies by Walker & Mpiranya (2005) and Walker et al. (2008) have shown that the 'š' series are in fact retroflex [ʂ, ʐ, ɳ͡ʐ]. As shown in (23), anticipatory retroflexion harmony is obligatory in transvocalic contexts, when the two fricatives are onsets of adjacent syllables. Note that the retroflexion of the triggering sibilant is often derived caused by a following /i/, such as agentive /-i/ (23a) or the first portion of the perfective suffix represented here (following Walker & Mpiranya 2005) as /-i-e/ (23b). No harmony applies in retroflex…alveolar sequences, as illustrated in (23c); the retroflexion harmony is strictly anticipatory, and there is no (anticipatory) 'alveolarity' harmony. Here and in what follows, all Rwanda data are cited from Walker & Mpiranya (2005) unless otherwise noted.

(23) Rwanda: obligatory sibilant harmony in transvocalic contexts

a.	/-sas-i/	[-ʂa.ʂi]	'bed maker'	(*[-sa.ʂi])
	/-soːn͡z-i/	[-ʂoː.ɳ͡ʐi]	'victim of famine'	(*[-soː.ɳ͡ʐi])
b.	/-sáːz-i-e/	[-ʂáː.ʐe]	'became old (perf.)'	(*[-sáː.ʐe])
	/-úzuz-i-e/	[-ú.ʐu.ʐe]	'filled (perf.)'	(*[-ú.zu.ʐe])
c.	/-ʂit-i-e/	[-ʂi.se]	'penetrated (perf.)'	(*[-sise], *[-ʂi.ʂe])

When the sibilant trigger-target pair are further apart, such that one or more consonants intervene between the two, enforcement of harmony is merely optional, resulting in free variation, as shown in (24).

(24) Rwanda: optional sibilant harmony in longer-range contexts

/-sákuz-i-e/	[-ʂákuʐe] ~ [-sákuʐe]	'shouted (perf.)'
/-ásamuz-i-e/	[-áʂamuʐe] ~ [-ásamuʐe]	'opened mouth (perf.)'
/-zímagiz-i-e/	[-ʐímagiʐe] ~ [-zímagiʐe]	'misled (perf.)'

In the examples in (24), the intervening consonants are all non-coronals: labial or dorsal consonants. When a non-retroflex *coronal* consonant (including the palatals [ɲ, j]) intervenes between the two sibilant fricatives, the option of enforcing harmony is not available, as shown in (25). In other words, such intervening coronals are *opaque* to sibilant harmony. Note that this includes the affricate [ts], which does not participate in the harmony (only sibilant fricatives do).

(25) Rwanda: blocking my non-retroflex coronals

/-síːtaːz-i-e/	[-síː.taː.ʐe]	'made stub (perf.)'	(*[ʂíːtaːʐe])
/-zíg-an-i-iʐe/	[-zí.ga.ni.ʐe]	'economized (perf.)'	(*[-ʐíganiʐe])
/-setsaguz-i-e/	[-se.tsa.gu.ʐe]	'caused to carve up (perf.)'	(*[-ʂetsaguʐe], *[-ʂeʈʂaguʐe])

The retroflex coronal [ɽ]—which is not itself an assimilation trigger (cf. [-so.ɽa] 'pay tax')—is *transparent* to the (optional) long-range retroflexion harmony between sibilant fricatives, just like non-coronals are. This is seen in examples like (26).

(26) Rwanda: transparency of retroflex [ɽ]

/-seɽuz-i-e/	[-ʂe.ɽu.ʐe] ~ [-se.ɽu.ʐe]	'provoked (perf.)'
/-togoseɽez-i-e/	[-to.go.ʂe.ɽe.ʐe] ~ [-to.go.se.ɽe.ʐe]	'made boil for (perf.)'

In an articulatory (EMMA) study of Rwanda sibilant retroflexion harmony, Walker et al. (2008) corroborate the coronal opacity facts illustrated in (25). The intervening [t] in the blocked-harmony form [βasataʐe] was entirely unaffected, indistinguishable from that of [βa-sataze] (both are nonce forms). Interestingly, Walker et al. found that intervening non-coronals *are* affected by the harmony property in those cases where harmony is (optionally) enforced across an intervening syllable. That is, the 'tip-up' gesture characteristic of retroflex [ʂ, ʐ] is found on the medial [m] of [βaʂamaːʐe] 'who are attractive' and [k] of [βaʂakáːʐe] 'who have covered (the roof) with' (as compared to the minimally contrastive retroflex-free [βasamaːze] 'let them be attractive', [βasakáːze] 'let them cover (the roof) with'). There is thus clear evidence that in Rwanda, harmony is achieved by means of strictly-local feature spreading (gestural extension), rather than by the trigger and target sibilants each carrying their own retroflexion feature/gesture.

Interestingly, Walker et al. (2008) find that an intervening [m] or [k] is affected by the retroflexion gesture *only* when the sibilant fricative target on its other side is targeted. (Recall from (24) that in its long-range version, harmony is optional.) That is, no retroflexion was detected on [m, k] in the variant pronunciations [βasamaːʐe], [βasakáːʐe].[22] This is highly significant, because it contradicts Walker & Mpiranya's (2005) analysis in terms of a constraint SPREAD-L[retroflex]; because harmony is obligatory in adjacent-syllable contexts (cf. (23) above), the [m] of […maːʐe] should be a target for spreading regardless of whether or

[22] Curiously, the same was not true for intervening [ɽ], which seemed to show signs of being targeted irrespective of whether long-range harmony was being enforced or not ([βasaɽaʐe] ~ [βaʂaɽaʐe] 'they made someone lose voice').

not that spreading also reaches some sibilant earlier in the word.[23] On the other hand, the 'contingent' spreading that Walker et al. (2008) document is exactly what we expect to see if the Rwanda harmony is a matter of retroflexion agreement between sibilant fricatives, and (strictly-local) spreading is merely the *means* for achieving this long-distance agreement rather than an end in itself (Hansson 2007b). Moreover, this otherwise unexpected 'non-myopic' or 'sour grapes' behavior in harmony (Wilson 2003, 2006, McCarthy 2004, Finley 2008) is precisely the predicted outcome in such 'agreement by spreading' interactions (Hansson 2007b; for a case of similarly 'non-myopic' vowel harmony, see Walker 2009a).

Finally, Walker et al. (2008) found that the prenasalized /n͡d/ of Walker & Mpiranya (2005; see also Kimenyi 1979) is phonetically retroflex [ɳ͡ɖ]. This makes its opaque behavior ([βasaːɳ͡ɖaːʐ̜e] 'they blew up'; *[βaʂ̜aːɳ͡ɖaːʐ̜e]) somewhat surprising, as compared to the transparency of retroflex [ɽ] seen in (26) above. As one possible explanation for this state of affairs, Walker et al. (2008) point out that the [n͡d] > [ɳ͡ɖ] change is likely a recent innovation in Rwanda, and that the harmony patterns might reflect the earlier alveolar pronunciation of this phoneme.

Another case which appears to involve segmental opacity effects in what otherwise gives the appearance of long-distance consonant agreement is the peculiar sibilant harmony found in Imdlawn Tashlhiyt Berber (Elmedlaoui 1995a). This case is unusual in that sibilant fricatives undergo assimilation both in [±anterior] and, under certain conditions, in voicing as well ([s] ~ [ʃ] ~ [z] ~ [ʒ]). It is only the voicing assimilation that is subject to an opacity effect; any intervening voiceless obstruent blocks voicing harmony between sibilants, whereas all voiced segments are transparent. The basic pattern is illustrated in (27), where the causative prefix /s-/ (which often surfaces as geminated due to templatic factors) alternates in voicing and anteriority; the (27a) examples demonstrate that the fricative of the prefix is underlyingly voiceless and [+anterior]. Pharyngealization ('emphasis') is marked with a diacritic [ˤ], on consonants and vowels alike, rather than the traditional underdot used by Elmedlaoui (1995a). Also, note that the effects of bidirectional pharyngealization spreading have been added in the transcription; in most of the relevant examples, Elmedlaoui represents pharyngealization only on the underlying source consonant(s).

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[23] Furthermore, the SPREAD-L[retroflex] analysis predicts that retroflexion spreading should also continue *beyond* the targeted [ʂ̜] in cases like [-to.go.ʂ̜e.ɽe.ʐ̜e] in (26), affecting the earlier [g] as well. Unfortunately, Walker et al. (2008) did not test for this in their study.

(27) Imdlawn Tashlhiyt: sibilant harmony alternations (Elmedlaoui 1995a)[24]

	Base	*Causative*	
a.	gdʷm	s-gdʷm	‘arrange upside down’
	rfufn	s-rfufn	‘manhandle’
	nkr	sː-nkr	‘rise’
	uga	sː-uga	‘be evacuated’
b.	nsa	sː-nsa	‘spend the night’
	rks	sː-rks	‘shy away, evade’
	asːtwa	s-asːtwa	‘settle, be levelled’
c.	ɦaʃr	ʃ-ɦaʃr	‘be full of straw, of discord’
	bːukʃːa	ʃ-bukʃːa	‘be full to overflowing’
	bˤːrˤbˤʃˤ	ʃˤ-bˤrˤbˤʃˤ	‘be gaily-coloured’
d.	bruzːa	z-bruzːa	‘crumble’
	nza	zː-nza	‘be sold’
	gʷˤrˤaˤzˤ	zˤː-gʷˤrˤaˤzˤ	‘regret’
e.	mːʒdawl	ʒ-mːʒdawl	‘stumble’
	gˤrˤuˤʒˤːmˤ	ʒˤ-gˤrˤuˤʒˤːmˤ	‘be extinguished (in cooking)’
	nʒm	ʒː-nʒm	‘escape (a misfortune)’

The same harmony pattern is manifested morpheme-internally, where sibilants differing in [±anterior] and/or [±voice] do not co-occur. With respect to voicing, Elmedlaoui (1995a:32–33) points out that the generalization is in fact broader: obstruents differing in voicing (/t…d/, /g…k/, /χ…ʁ/) never co-occur within a root (Willms 1972:40 makes the same observation about closely related Tamazight).[25] Elmedlaoui points out that several loanwords from Arabic surface with unrepaired [ʃ…ʒ] or [ʒ…ʃ] sequences in Imdlawn Tashlhiyt, and takes this as evidence that the voicing restriction is not actively enforced morpheme-internally (e.g. /ʃːariʒ/ ‘pond, pool’, /lʒiʃ/ ‘army’). Nevertheless, he elsewhere cites an example of a borrowing from French in which sibilant voicing harmony is enforced: /zizi/ < Fr. *saisir* /seziʁ/ ‘seize, grab’.

The examples in (28) show how the sibilant voicing harmony is blocked by an intervening voiceless obstruent (28a–b), whereas voiced obstruents are transparent to the harmony (28c, repeated from 27d–e). Cases like those in (28b) demonstrate that when voicing harmony is blocked, harmony in [±anterior] still applies as appropriate. Note that the last example in each of (28a) and (28b) contains the reciprocal prefix /m-/.

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24 The glosses provided (translated from French) pertain to the verbal base form on the left, rather than to the causativized form.

25 This distributional generalization is likely a reflection of the pervasive *similarity avoidance* patterns found elsewhere in Afro-Asiatic languages, such as in the Semitic branch (see, e.g., Frisch et al. 2004 on Arabic).

(28) Imdlawn Tashlhiyt: sibilant voicing harmony blocked (Elmedlaoui 1995a)

	Base	*Causative*	
a.	ħuz	s-ħuz	‘annex’
	ukz	sː-ukz	‘recognize’
	rˤuˤfˤːzˤ	sˤ-rˤuˤfˤzˤ	‘appear resistant, recalcitrant’
	rkz	sː-rkz	‘dance’
	m-χazaj	s-m-χazaj	‘loathe each other’
b.	fʒːiʒ	ʃ-fʒːiʒ	‘go for a walk (for pleasure)’
	qːuʒːi	ʃ-quʒːi	‘be dislocated, broken’
	nːuqːʒ	ʃ-nuqːʒ	[no gloss]
	mˤ-ħˤaˤrˤaˤʒˤ	ʃˤ-mˤ-ħˤaˤrˤaˤʒˤ	‘get angry with each other’
c.	bruzːa	z-bruzːa	‘crumble’
	gʷˤrˤaˤzˤ	zˤː-gʷˤrˤaˤzˤ	‘regret’
	gˤrˤuˤʒˤːmˤ	ʒˤ-gˤrˤuˤʒˤːmˤ	‘be extinguished (in cooking)’

It is worth noting that the opaque voiceless obstruent need not be adjacent to the target sibilant; the failure of voicing harmony in (28a–b) is thus not a matter of local assimilation in obstruent clusters (regressive [–voice] assimilation) overriding the effects of the long-distance voicing harmony (see Elmedlaoui 1995a:31 for discussion on this point).[26]

For Agadir Tashlhiyt, Lahrouchi (2003) cites examples like those in (29). His description of the opacity effect, which is illustrated in (29d), is like that of Elmedlaoui (1995a): voicing harmony can only apply if any and all intervening segments are voiced. However, in (29d) the voiceless obstruent is directly adjacent to the prefixal sibilant, which would not exclude local [–voice] assimilation as a possible cause for the observed disharmony.[27]

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[26] Imdlawn Tashlhiyt does have such a regressive [–voice] assimilation process, seen in cases like /t-alqːaʁ-t/ → [talqːaχt] ‘lamb (fem.)’, /t-amdːuz-t/ → [tamdːust] ‘garbage bin (fem.)’. According to Elmedlaoui (1995a:29 n.14) this is one of the features that sets the Imdlawn dialect apart from many other Tashlhiyt dialects (of which he mentions Indawzal and Zagmuzn). Interestingly, when it targets a root-internal /z/ or /ʒ/, this local devoicing has the effect of rendering the sibilant voicing harmony *derivationally opaque*: consider examples such as /t-a-s-agʷz-t/ (→ [tazagʷzt]) → [tazakʷst] ‘place of descent (fem.)’, or [zː-usf] (← /sː-uzf/), causative counterpart of [azuf] ‘be uncovered’ (Elmedlaoui 1995a:30–31).

[27] Lahrouchi (2003, 2005) observes that sibilant harmony in the Agadir dialect is also subject to a morphological domain restriction, in that it does not reach across an intervening prefix such as reciprocal /m-/ (which dissimilates to [n-] before stems containing a labial); compare the simple causative [ʃ-ħəʃːəm] ‘make shy, embarrass’ to the causativized reciprocal form [s-n-ħəʃːəm] ‘cause mutual embarrassment’. In this respect, Agadir Tashlhiyt seems to differ from the Imdlawn dialect, as is evident from [ʃˤ-mˤ-ħˤaˤrˤaˤʒˤ] in (28b) above as well as [ʃˤ-nˤ-fˤaˤrˤːaˤʒˤ] from [fˤrˤːʒˤ] ‘watch for fun’ (Elmedlaoui 1995a:32).

(29) Agadir Tashlhiyt: sibilant harmony (Lahrouchi 2003)

	Base	*Causative*	
a.	mijːəl	s-mijːəl	'tilt (intr.)'
	nkər	sː-ənkər	'rise'
b.	kuʃəm	ʃ-kuʃəm	'be paralyzed'
	rʃa	ʃː-ərʃa	'be dilapidated, rotten'
c.	uʒad	ʒː-uʒad	'prepare'
	nʒəm	ʒː-ənʒəm	'save'
d.	fərːəʒ	ʃ-fərːəʒ	'amuse, entertain'
	fəʒːiʒ	ʃ-fəʒːiʒ	'be good'

For the closely related Tamazight, Penchoen's (1973) description of the Ayt Ndhir dialect (spoken around El Hajeb) also seems consistent with the pattern described above. Though Penchoen does not describe the harmony alternations in detail, and makes no explicit mention of the conditions under which voicing harmony might be blocked, examples like those in (30)–(31) closely match Elmedlaoui's description of Imdlawn Tashlhiyt. It is interesting to note that the affricates [tʃː, dʒː] (which are the morphophonemically 'tensed' counterparts of /ʃ, ʒ/) seem to trigger [–anterior] harmony as well. Note also that [ç] in the forms in (31) reflects the general lenition of singleton stops (and /k, ɡ/ in particular) that is widespread in many Tamazight dialects; it thus corresponds to Imdlawn [k] in some of the examples in (28) (in fact, (31a) is cognate with the second example of (28a)). The only thing that is odd about (31) is the absence of [±anterior] harmony in (31b); it is conceivable that this is due to the palatality of the intervening [ç].

(30) Ayt Ndhir Tamazight: sibilant harmony alternations (Penchoen 1973)

	Base		*Causative*	
a.	rwəl	'flee, run'	sː-ərwəl	'cause to flee, rout'
b.	ətʃː	'eat'	ʃː-ətʃː	'feed'
c.	ənz	'be salable'	zː-ənz	'sell'
			zː-uzːər	'sprinkle' [base not provided]
d.	ʒːəj	'get well'	ʒː-uʒəj	'heal (tr.)'

(31) Ayt Ndhir Tamazight: sibilant harmony blocked? (Penchoen 1973)

	Base		*Causative*	
a.	açəz	'recognize'	sː-içəz	'cause to recognize'
b.	çʒəm	'enter'	sː-əçʒəm	'introduce, put in'

Judging by Willms (1972), sibilant harmony is somewhat less regular in the more southerly Tamazight dialects he describes. Though Willms describes the total assimilation of causative

/sː-/ to a root-internal /ʃ/ or /z/ as 'very common', he does also cite unharmonized instances like [sː-ətʃ] 'feed' and [sː-izːəl] ~ [sː-azːəl] 'make run' alongside harmonized [ʃː-ətʃ], [zː-izːəl] (p. 61), as well as [sː-əʁzif] ~ [sː-uʁzif] vs. [zː-əʁzif] 'lengthen' (p. 107).[28] Other unharmonized forms include [sː-luzˤ] 'cause to starve' (p. 103) and [sː-kuʃəm] 'bring in' (p. 107; cognate with (31b)). Interestingly, Willms (1972) makes no mention at all of [ʒ] as a possible realization of /s/ resulting from harmony, and cites no examples of the relevant kind.

While Tashlhiyt and Tamazight belong to the Northern Berber branch, a similar pattern of sibilant harmony in anteriority and voicing is also found in the Southern Berber or Tuareg branch. What is particularly striking about the Tuareg pattern is that voiceless obstruents are here *transparent* to the voicing harmony rather than opaque. The examples shown in (32) are drawn from the Tamajaq (Tawellemmett and Tayert) dialects of Niger covered in Alojaly (1980).

(32) Tamajaq Tuareg: sibilant harmony without blocking (Alojaly 1980)

	Base		*Causative*	
a.	əlməd	'learn, study'	s-əlməd	'teach, inform'
	əχrək	'err, be lost'	s-əχrək	'mislead, lead astray'
	əwəsˤ	'boil (intr.)'	s-əwəsˤ	'boil (tr.)'
	qusət	'inherit'	s-əqːusət	'cause to inherit'
	busu	'be injured'	s-əbːusu	'injure'
b.	măʃăn	'be overwhelmed'	ʃ-əmːəʃən	'overwhelm'
	ătʃu	'eat'	ʃ-ătʃu	'feed'
	fərəʃːət	'be ugly, humiliated'	ʃ-əfːərəʃːət	'make ugly, humiliate'
	əɣʃəd	'destroy, spoil'	ʃ-əɣʃəd	'cause to spoil'
c.	əkləzˤ	'invent'	z-əkləzˤ	'cause to invent'
	əntəz	'pull out, extract'	z-əntəz	'cause to extract'
	əlfəzˤ	'squash, flatten'	z-əlfəzˤ	'cause to squash'
	əbzəg	'be mad, panic'	z-əbzəg	'drive mad, cause to panic'
	guləz	'be left, remain'	z-əgːuləz	'cause to remain'
d.	kuʒət	'saw (v.)'	ʒ-əkːuʒət	'cause to saw'
	fănʒăr	'have a torn nose/ear'	ʒ-əfːənʒər	'tear one's nose/ear'
	əgʒəʒ	'crave, insist'	ʒ-əgʒəʒ	'cause to crave'
	ăɣʒu	'be amazed'	ʒ-ăɣʒu	'amaze'

Corresponding examples abound in Sudlow's (2001) description of the Tamajaq (Tudalt, or Western Tawellemmett) and Tamashek (Tadraq) dialects spoken in the northeastern part of

[28] Willms (1972) gives all examples in traditional phonemic transcription and omits the [ə] vowel which he considers epenthetic; I have here attempted to 'restore' [ə] based on Willms' general description of where epenthesis occurs, perhaps incorrectly in some cases.

Burkina Faso. Cases where sibilant voicing harmony extends across a voiceless obstruent include [ʒ-əkːəmbəʒ] 'be veiled, put on head scarf', [ʒ-əqːəʒəm] 'clear throat (menacingly)' and [zˤ-əkːənzˤăr] 'be troubled, sad, upset'. The same goes for the Tamashek (Taneslemt) dialects of Mali described by Heath (2005). Among the examples he cites are [zˤ-ìhəzˤ] 'make approach!' and the complex verbal noun [ɑ-zˤ-ənː-ət-ə́lməzˤ] 'act of swallowing and spitting up saliva', in which both passive /t-/ and reciprocal /m-/ (dissimilated to [n] due to the root-medial [m]) intervene between the /s-/ prefix and the root.[29]

Several arguments support the inclusion of the Berber sibilant alternations among the consonant harmony systems surveyed in this work. For one thing, the existence of languages/dialects in which all intervening segments are transparent to the long-distance voicing assimilation suggests that the driving force behind the harmony alternations is some kind of demand for 'agreement' or assimilation between (potentially) non-adjacent pairs of segments. Secondly, the interaction clearly involves a relation *between sibilants*: no other voiced obstruents trigger voicing in an /s/ earlier in the word, and no voiceless obstruent other than /s/ undergoes voicing assimilation (for example, passive /t-/ does not). It is noteworthy that the outcome of [±voice] and [±anterior] harmony is typically total assimilation (modulo the opacity effects in (28) and the issues pertaining to pharyngealization; see n. 29 above). It is conceivable that the constraint(s) triggering the long-distance sibilant assimilations in Berber are ones which demand complete identity as such rather than agreement in specific individual features (see Gallagher 2008, Gallagher & Coon 2009; cf. §4.1.2 below). Even so, the importance and relevance of the Berber case lies in the fact that it displays assimilatory interaction at-a-distance between consonants belonging to a narrowly circumscribed natural class, and that this non-local assimilation *can* be disrupted by intervening consonants which carry a conflicting value for the (voicing) feature being propagated from trigger to target. It is quite

[29] Sudlow (2001) and Heath (2005) both transcribe the /s-/ prefix as also taking on the *pharyngealization* of the triggering sibilant (when the latter is /zˤ/ or the less common /sˤ/), in addition to its [±voice] and [±anterior] specifications. In such cases, Alojaly (1980) systematically transcribes the prefixal [z-] as being *non*-pharyngealized, as can be seen from several of the examples in (32) above. Such apparent differences should be taken with a grain of salt, however; in all Berber languages, pharyngealization spreads beyond the segment, often throughout much or all of the word, and the domain for this spreading is seldom laid out clearly in descriptive sources. It is therefore possible that pharyngealization reaches the prefix sibilant not by means of a *direct* sibilant-to-sibilant interaction (as is surely the case with the [+voice] feature) but rather due to a general spreading of pharyngealization across the whole word, and that Alojaly (1980) is simply omitting this predictable effect from his transcriptions. Nevertheless, Heath (2005:36) notes that the effect of pharyngealized consonants on nearby segments is at its weakest precisely in those Tamajaq dialects of Niger that Alojaly (1980) is describing. This might be taken to suggest that the sibilant harmony in those dialects involves [±voice] and [±anterior] to the exclusion of [±RTR], and that sibilant harmony does not necessarily result in total assimilation of target to trigger.

likely that the Imdlawn Tashlhiyt facts in (27)–(28) can be attributed to the same kind of 'agreement by spreading' suggested earlier for Rwanda sibilant harmony (Hansson 2007b).

As we have seen above, segmental opacity effects are not completely unheard of in consonant harmony. However, they are exceedingly rare, especially in comparison to vowel harmony and vowel-consonant harmony, and this striking asymmetry cries out for an explanation. In this work, where consonant harmony is interpreted as being triggered by constraints that call for featural agreement between (potentially) non-adjacent segments of a particular class, rather than spreading between adjacent segments, the consistent transparency of intervening segments is what we expect to find. Even though opacity effects *can* in fact be generated in an agreement-based analysis (Hansson 2006a, 2007a, Rhodes 2008, Walker 2009b), and even though local spreading can provide the means for achieving non-local agreement (Hansson 2007b), such effects are the product of highly specific constraint-ranking configurations. This means that the default behavior of intervening segments in consonant harmony—even ones which carry properties that are incompatible with the 'spreading' feature—is for them to be fully transparent to the assimilatory interaction between the consonants on either side.

3.2.2.3. Proximity Restrictions and Other Locality Issues

There are a number of consonant harmony systems that may at first glance appear to display opacity effects—in the sense that *all* non-participating consonants seem to act as blockers—but where this is better understood as a *proximity* restriction on trigger-target pairs rather than the nature of intervening non-undergoers.

Consonant harmony systems are quite often sensitive to trigger-target distance. For example, related languages displaying similar (and historically cognate) harmonies may differ in the maximum distance allowed between two interacting consonants; several such cases were discussed in chapter 2. Sibilant harmony in Omotic languages (§2.4.1.1) may be unbounded (Aari, Benchnon) or it may apply only in 'transvocalic' contexts (i.e. in CVC sequences; Koyra, Zayse). An analogous dichotomy is found in Bantu nasal consonant harmony (§2.4.4), between unbounded harmony (Yaka, Kongo) and transvocalic harmony (Bemba, Lamba, Luba, and others). In some cases, harmony is obligatory at shorter distances but optional when the target is further away. Among the aforementioned Bantu languages, Suku appears to be an example of this (Piper 1977), where nasal consonant harmony applies obligatorily in transvocalic contexts and optionally in (certain) long-distance contexts. Similarly, Bukusu liquid harmony (§2.4.5) appears to be obligatory in transvocalic environments (/CVr-Vl-/) but optional at greater distances (/rVC-Vl-/, /CVrVC-Vl-/). In Nkore-Kiga sibilant harmony, disharmonic […ʃVs…] sequences are prohibited but […ʃVCVs…] is allowed (whereas […s…ʃ…] is prohibited regardless of distance).[30]

[30] See §5.1.2 and §5.3.3 for detailed discussion of the Nkore-Kiga case and the theoretical implications of the asymmetry described here.

In addition, descriptions of sibilant harmony systems in a variety of languages make some mention of the potential effect of relative trigger-target distance, without illustrating or clarifying this in any detail. For example, in his discussion of Ineseño sibilant harmony, Applegate (1972:199) remarks that occasional exceptions to harmony do occur, ‘particularly across longer words’. Cook (1979:27), when describing sibilant harmony in Tsuut’ina (Sarcee), notes that it ‘becomes gradually weaker as it gets farther from the palatal sibilant which originally triggers the process’. Sapir & Hoijer (1967:14–15) make a similar comment about Navajo sibilant harmony, describing it as being ‘conditioned by the distance between the prefix consonant and that to which it is assimilated’; they go on to say that assimilation ‘nearly always occurs when the two consonants are close together’, but that it ‘occurs less often when the two consonants are at a greater distance’ (see also McDonough 2003:49). It is interesting to note that the examples Sapir & Hoijer cite to illustrate the former situation involve transvocalic assimilation ([SV.SV] and [SVS.CV] contexts)—where nothing separates the two sibilants except vocalic material—whereas in the latter case, where they claim harmony is less pervasive, the context in their example is [SV(C).CVS]; we shall return to this point below.[31]

There are thus numerous examples of consonant harmony being sensitive to the proximity of the trigger and target consonants. Frequently harmony applies across a vowel, but not across longer stretches of vowels and consonants. Most languages of this kind happen to have fairly simply syllable structure, with no complex onsets and either no closed syllables or else a severely limited inventory of possible coda consonants. For this reason, it is often possible to interpret the limitation of harmony to ‘transvocalic’ contexts a having to do with *syllable adjacency*. From this alternative perspective, harmony fails to apply between C_x and C_y in a string C_xV.CV.C_yV (while being enforced in C_xV.C_yV) not because of the intervening consonant as such but because C_x and C_y are not in adjacent syllables (for formal implementations of this idea, see Odden 1994 and Rose & Walker 2004).

In practice, it is very difficult to ascertain whether syllable adjacency is the relevant notion or rather some other proximity metric. The crucial evidence would need to come from languages with more complex syllable structure: ones that allow closed syllables (with few restrictions on possible codas) and/or complex onsets. The syllable-adjacency hypothesis predicts the possibility of a syllabification-based split among …C_xV(C)CVC_y… cases, such that C_y will harmonize with C_x when it is parsed as a coda (word-finally, or when followed by another C) but not when parsed as an onset (i.e. when followed by a vowel). The syllable-adjacency hypothesis further predicts that no consonant harmony system should ever dis-

[31] Sapir & Hoijer (1967:16) note that there are also *morphological* limitations on sibilant harmony in Navajo, which are independent of this distance effect. Thus prefixes in the so-called disjunct domain do not undergo harmony, even when followed closely by a sibilant. Likewise, enclitics do not trigger harmony in the immediately preceding stem, and harmony occurs only rarely between the two members of a compound (though for a more subtle influence of sibilant harmony on Navajo compound formation, see Martin 2005, 2007).

criminate between C_xVC_y on the one hand and $C_xV(C).CVC_y$ on the other (with C_y in coda position in both cases), enforcing harmony in the former but not the latter.[32]

The closest we can come to testing these predictions is by looking at the patterning of sibilant harmony in those Omotic languages in which the harmony is 'transvocalic' rather than unbounded, namely Zayse and Koyra (see §2.4.1.1). Zayse (Hayward 1990) does allow obstruents in word-final position (/ʃóːʃ/ 'snake', /dóbes/ 'python', /k'azats/ 'beggar'), and fricatives can occur as codas before a following stop onset (/diʃkaró/ 'millet', /pistá/ 'sprinkle!'). This would have made Zayse an ideal test case, were it not for the fact that outside of root morphemes, sibilant harmony in Zayse is limited to the causative suffixes /-s/, /-us/, /-ats/, and it appears that for purely morphological reasons these are always followed by a vowel-initial suffix (e.g. the 'post-thematic vowel' /-a/), such that the sibilant of the causative suffix always surfaces in onset position. As for Koyra (Hayward 1982, Ford 1990), its sibilant harmony is less morphologically restricted, targeting inflectional suffixes in addition to causative /-s/, /-us/. However, Koyra syllable structure is much more constrained than that of Zayse: only sonorants are allowed in (word-medial) coda position, and word-final codas are banned altogether. In short, the combined effects of restrictions on morphotactics and syllable structure would seem to prevent us from using either of these languages as a test case.

There is, however, one way in which evidence from Koyra and Zayse can be brought to bear on the 'transvocalic' vs. adjacent-syllable question. Both languages do allow word-medial *geminate* consonants, including sibilant fricatives or affricates (Koyra /bítsːo/ 'one', /kap-esːe/ 'watch, guard (3Pl. jussive)', /ʔáʃːa/ 'mouth'). Such geminates presumably involve a single segment (root node) straddling the syllable boundary, and hence simultaneously belonging to the coda of one syllable and the onset of the next. From this perspective, the failure of sibilant harmony in the 3SgM jussive ending /-esːe/ in [ʃo.des.se] 'let him uproot!', in contrast to its enforcement in [miː.tʃ'eʃ.ʃe] 'let it burn!' becomes a challenge for the syllable-adjacency hypothesis. Since in [ʃo.des.se] the suffixal /s/ is located in the immediately adjacent syllable (if only partly so), we ought to expect it to fall within the scope of sibilant harmony. The 'transvocalic' hypothesis, by contrast, whereby the crucial factor is presence vs. absence of an intervening consonant, makes the correct prediction in this case.

In order for the syllable-adjacency hypothesis to accommodate facts like these, its proximity requirements would have to be formulated very carefully, by requiring interacting segments to be *wholly* contained within adjacent syllables. This would correctly account for the failure of harmony in forms like [ʃo.des.se], due to the ambisyllabic affiliation of the [sː].

[32] In theory, one could imagine enforcing consonant harmony *within* a syllable without doing so between syllables (even adjacent ones); in other words, that there exist three possible proximity 'thresholds' for (long-distance) consonant assimilations: tautosyllabic vs. adjacent-syllable vs. unbounded. This would allow a language to differentiate between C_xVC_y and $C_xV(C).CVC_y$, as described above. (Note that harmony would then also *not* be applied in $C_xV.C_yV$ contexts.) However, nothing resembling such a 'syllable-domain' or tautosyllabicity restriction is attested in consonant harmony systems.

However, this erroneously predicts that geminate sibilants should also fail to *trigger* harmony, even across a single vowel. For example, we should find harmony in Koyra /ʔordʒ-d-osːo/ → [ʔor.dʒoʃ.ʃo] 'he got big' but not in /giːʒ-d-osːo/ → [giːʒ.ʒoʃ.ʃo] 'it suppurated', because in the latter form the two (geminate) sibilants are partly in non-adjacent syllables. Likewise, in a form like /dʒaʃ-us-d-osːo/ → [dʒa.ʃuʃ.ʃoʃ.ʃo] 'he frightened, caused to be afraid', we should expect harmony to affect the causative suffix /-us/ but not the 3SgM perfective ending /-osːo/, yielding *[dʒa.ʃuʃ.ʃos.so], for the same reason.[33] Similarly, in Zayse we would expect harmony in causative /-us/ or /-ats/ to fail when the stem-final trigger is a geminate sibilant, but this does not appear to be the case. Hayward (1990) reports cases like /ʃitʃː-us-/ → [ʃitʃːuʃ-] and /ʃitʃː-ats-/ → [ʃitʃːatʃ-] 'cause to roast grain' alongside /haːtʃ'-us-/ → [haːtʃ'uʃ-] 'cause to scrape/scratch' and /moːʒ-us-/ → [moːʒuʃ-] 'make cold'.

In addition to this problematic evidence from Omotic sibilant harmony, the aforementioned description of distance effects in Navajo sibilant harmony by Sapir & Hoijer (1967:14–15) may also be taken to suggest that the syllable-adjacency approach to proximity restrictions is on the wrong track. The sole example cited by Sapir & Hoijer as illustrating those contexts where harmony is applied *less* consistently involves sibilants in an environment that ought to be entirely unproblematic from the point of view of syllable adjacency: [ʔà.dʒìːɬ.táːs] ~ [ʔà.dzìːɬ.táːs] 'he (4th person) bends things' (← /ʔa-dʒi-(j)i-ɬ-táːs/). Their examples of environments with *more* consistent harmony include both tautosyllabic (onset-coda) and heterosyllabic (onset-onset) sibilant pairs: [dzìz.tí̃] 'he (4th p.) lies' (← /dʒi-s(i)-tí̃/) and [ʃì.dʒàːʔ] 'a mass [of small things] lies' (← /si-dʒàːʔ/). This indicates that some factor other than syllable adjacency is at play. Again, the simple criterion of 'transvocalic' (vs. longer-distance) consonant pairs appears to provide a better match with the observed asymmetry.

For precisely these reasons, the formal analysis of chapter 4 (see esp. §4.2.1.1) models proximity restrictions not in terms of syllable adjacency (as Rose & Walker 2004 do) but in terms of a more concrete—and admittedly stipulative—notion of 'transvocalic' C…C pairs. It should be emphasized, however, that much is yet unclear about how distance-related restrictions on consonant harmony are best interpreted (and implemented formally), and this remains as an important question for future research. In any case, such restrictions are completely distinct from the kinds of opacity effects discussed and described in §3.2.2.1 and §3.2.2.2 above.

Finally, effects that superficially look like instances of segmental opacity may also occur when harmony is overridden by phonotactic constraints. Recall from §2.4.1.1 that in Ineseño and certain other Chumashan languages, anticipatory sibilant harmony interacts with an independent 'pre-coronal effect', whereby the sibilant /s/ dissimilates to [ʃ] before the non-sibilant

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[33] In Koyra, the /-d/ extension that forms the perfect stem undergoes total assimilation to a preceding coronal; hence the gemination of the sibilant of the causative /-us/ suffix in this last example (cf. /kap-d-osːo/ → [kat.tos.so] 'he guarded [it]', /kap-us-d-osːo/ → [ka.pus.sos.so] 'he had [it] guarded'), as well as of the root-final /ʒ/ in /giːʒ-d-osːo/ → [giːʒ.ʒoʃ.ʃo].

alveolars [t, l, n]. (The change only takes place across a morpheme boundary, but this aspect of it will be ignored here; for details see Poser 1982, 1993, McCarthy 2006.) When sibilant harmony would be expected to give rise to (heteromorphemic) clusters like [st] or [sl], it is blocked from applying; this is illustrated by the examples in (33), repeated from §2.4.1.1.

(33) Ineseño: sibilant harmony overridden by pre-coronal s → ʃ

a.	/s-ti-jep-us/	ʃtijepus	'he tells him'
b.	/s-iʃ-lu-sisin/	ʃiʃlusisin	'they (2) are gone awry'
c.	/s-is-tɨʔ/	ʃiʃtiʔɨ	'he finds it'

As seen in (33a–b), an [ʃ] which is part of a [ʃt], [ʃn] or [ʃl] cluster does not undergo harmony—that is, the demands of the precoronal effect override those of harmony. Furthermore, such a precoronal [ʃ] initiates its own harmonic span (33b–c). In cases like (33b), we do not see [+anterior] harmony being applied *across* the intervening […ʃl…] (that is, the outcome is not *[**s**iʃlu**s**i**s**in]); in this respect, we might label the precoronal [ʃ] 'opaque'. However, this has no bearing on the central issue of concern, namely whether intervening *non*-sibilants (including vowels) are targeted (permeated) by the harmonizing property or not. All that the 'opacity' of precoronal [ʃ] tells us is that *it* is a (potential) target—but we already know this; in a sibilant harmony system, sibilants are by definition eligible targets.

The fact that [ʃ] in pre-coronal position blocks harmony rather than being transparent to it, yielding *[siʃlusisin] in (33b), is significant in itself, but not too surprising. In a sibilant harmony system, a multi-sibilant sequence /…S_i…S_j…S_k…/ is comparable to a vowel sequence /…V_i…V_j…V_k…/ in a vowel harmony system. If something causes V_j or S_j to be a non-undergoer—say, an incompatibility (context-free or context-sensitive) with the value for [±F] being transmitted by harmony—this may or may not interfere with an assimilatory relation holding between V_i and V_k, or S_i and S_k.[34] In fact, it would have been perfectly conceivable in principle for [ʃ] to act as transparent in (33b). A somewhat analogous case seems to occur in Rundi (Kirundi; Bantu), where the /ʃ/ of causative /-iʃ/ (exceptionally) fails to trigger sibilant harmony, while also being reported to be transparent to harmony emanating from a later suffix (Ntihirageza 1993).

3.2.3. Sanskrit N-Retroflexion: Spreading, not Consonant Harmony

Those familiar with the phonological literature on locality and long-distance interactions, and on coronal harmony in particular, may raise an eyebrow at the claim that consonant harmony systems almost universally fail to display segmental opacity effects. Of all the phenom-

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[34] It may prove necessary to impose locality restrictions on the evaluation of agreement (i.e. harmony) in such 'chains' of participating segments, as proposed by Hansson (2006b, 2007a) and Rhodes (2008); see also Krämer (2003:75–76) for related discussion.

ena traditionally discussed under the rubric of coronal harmony, one of the best known and most celebrated cases does show clear opacity effects. This is the process in (Vedic) Sanskrit known as *ṇati* or, as it will be referred to here, *n*-retroflexion. Aside from traditional descriptive accounts (Whitney 1889; cf. Allen 1953), Sanskrit *n*-retroflexion has received considerable attention in the phonological literature over the past several decades (Allen 1951, Johnson 1972, Schein & Steriade 1986, Sagey 1990, Humbert 1995, Steriade 1995a, Ní Chiosáin & Padgett 1997, Gafos 1999).

It will be argued here that Sanskrit n-retroflexion is not a case of consonant harmony (in the sense defined in this work). Rather, it is a fundamentally different kind of phenomenon, displaying a series of properties that are otherwise unattested or highly unusual in the typology of consonant harmony systems. The conclusion is that Sanskrit *n*-retroflexion is more akin to vowel-consonant harmony phenomena, (e.g. nasal harmony, emphasis spreading). As such, the Sanskrit process *does* appear to involve feature/gesture spreading—exactly as posited in most previous analyses. Given this interpretation, the otherwise anomalous characteristics of Vedic Sanskrit *n*-retroflexion, including the opacity effects that restrict its application, turn out to be far less surprising.

3.2.3.1. Basic Description

The (Vedic) Sanskrit consonant inventory is as presented in (34). The consonants are rendered here in the traditional way (e.g., using <c, j, ś> for the 'palatal' obstruents and <y> for the palatal glide), with a few exceptions: voiced aspirates (breathy-voiced stops) are transcribed as [b^h], [d^h], etc., the retroflex series as [ʈ ʈ^h ɖ ɖ^h ʂ ɳ], and the palatal nasal as [ɲ]. Note that the [t t^h d d^h s n l] series is traditionally referred to as 'dental'; this practice will be followed here. (See Allen 1953 for details on Sanskrit phonetics as described by the ancient grammarians of India.) Furthermore, length will be indicated by [ː] and syllabicity by [̩], instead of the traditional diacritic macron and subscript dot, respectively.

(34) Sanskrit consonant inventory

p	t	ʈ	c	k	
p^h	t^h	ʈ^h	c^h	k^h	
b	d	ɖ	j	g	
b^h	d^h	ɖ^h	j^h	g^h	
	s	ʂ	ś		h
m	n	ɳ	ɲ	ŋ	
v	l	r	y		

The process of *n*-retroflexion involves progressive assimilation. A continuant retroflex consonant (/ʂ/ or /r/) causes a dental nasal /n/ later in the word to surface as retroflex [ɳ], as illustrated in (35). The assimilation may take place under direct adjacency, when the /ʂ/ or /r/ trigger immediately precedes the target /n/ (35a). It also applies across a (non-coronal) consonant

(35b), and across a vowel (35c). Finally, examples like (35d) show that the triggering /ş, r/ and target /n/ may be separated by a considerable stretch of intervening segmental material.

(35) Vedic Sanskrit *n*-retroflexion (Schein & Steriade 1986)

a.	/iş-na:-/	işɳa:-	'seek (present stem)'
	/pu:r-na-/	pu:rɳa-	'filled (passive participle)'
	/tr=na=t-ti/[35]	tr̥ɳatti	'splits (3Sg active)'
b.	/vrk-na-/	vr̥kɳa-	'cut up (passive participle)'
	/grb^{h}-na:-ti/	gr̥b^{h}ɳa:ti	'seizes (3Sg active)'
c.	/cakş-a:na-/	cakşa:ɳa-	'see (middle participle)'
	/pur-a:na-/	pura:ɳa-	'fill (middle participle)'
d.	/kşub^{h}-a:na-/	kşub^{h}a:ɳa-	'quake (middle participle)'
	/krp-a-ma:na-/	kr̥pama:ɳa-	'lament (middle participle)'
	/brahman-i/	brahmaɳi	'brahman (LocSg)'

The process in (35) is blocked whenever a coronal consonant of any kind intervenes between the triggering /ş, r/ and the target /n/. This includes all dental, palatal, and even retroflex consonants, obstruents as well as sonorants.[36] Intervening coronals are thus *opaque* to the progressive assimilation in retroflexion. Examples illustrating the blocking behavior of coronals are given in (36).

(36) Vedic Sanskrit: opacity of intervening coronals (Schein & Steriade 1986)

/mrd-na:-/	mr̥dna:-	(*mr̥dɳa:-)	'be gracious (pres. stem)'
/marj-a:na-/	marja:na-	(*marja:ɳa-)	'wipe (middle part.)'
/krt-a-ma:na-/	kr̥tama:na-	(*kr̥tama:ɳa-)	'cut (middle part.)'
/kşved-a:na-/	kşveda:na-	(*kşveda:ɳa-)	'hum (middle part.)'

An additional striking property of *n*-retroflexion is that it is *non-iterative*, applying only to the first of a sequence of potential target nasals, rather than to all subsequent nasals in the word.

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[35] Here and in subsequent examples, infixation is indicated (in the input representation) by '=' on either side of the infix morpheme.

[36] Interestingly, the palatal glide /y/ does not appear to be opaque. In this respect, it behaves like a vowel rather than as a consonant.

(37) Vedic Sanskrit: retroflexion only targets the nearest nasal:

/pra-ninaːya/	praɳinaːya	(*praɳiɳaːya)	'lead forth' (/niː-/ 'lead')
/krn-vaːna/	kr̩ɳvaːna	(*kr̩ɳvaːɳa)	'make (middle part.)'
/varn-anaːnam/	varɳanaːnam	(*varɳaɳaːɳam)	[no gloss] (Ní Chiosáin & Padgett 1997)

Given certain assumptions, it seems feasible to connect the non-iterative character of *n*-retroflexion to its other properties, such as the class of triggers and opaque segments. For example, Gafos (1999) argues that when a sequence like /ʂ…n…n/ surfaces as [ʂ…ɳ…n], the second nasal does not undergo retroflexion simply because the preceding [ɳ] is not a trigger (only [ʂ, r] are). In other words, the derived [ɳ] behaves in exactly the same way as any other non-continuant retroflex, such as [ɖ] or [ʈ]. The resulting [ʂ…ɳ…n] is then comparable to [ʂ…ɖ…n] or [r…ʈ…n], with no retroflexion of the (distal) nasal. Retroflexion does not spread *from* the medial retroflex nasal or oral stop, since only retroflex continuants are triggers; retroflexion also does not spread *through* a medial stop (nasal or oral). This idea, that the non-iterative character of the process and the opacity of retroflex non-continuants can be reduced to a single factor—namely, that oral stops and nasals are non-triggers—hinges on certain assumptions which may not be valid; I will return to this below.

In addition to intervening coronals being consistently opaque, it appears that even non-coronal consonants can occasionally block *n*-retroflexion. When the target /n/ is immediately preceded by a non-coronal (labial or velar) stop or nasal, retroflexion applies variably, as noted in descriptive grammars: '[t]he immediate combination of *n* with a preceding guttural or labial seems in some cases to hinder the conversion to *ɳ*: thus *vrtrag^{h}naː* etc., *kʂub^{h}naːti*, *trpnoti* (but in Veda *trpɳú*), *kʂepnú*, *suʂumná*' (Whitney 1889, §129; transcriptions adapted). In other words, an intervening labial or velar sometimes acts as opaque to the propagation of retroflexion, the way an intervening coronal consistently does, though only when immediately adjacent to the target nasal. Steriade (1995b) dismisses this observed variation as being due to inaccurate transcription, arising from the fact that retroflexion in clusters like [gɳ] or [mɳ] has much weaker auditory consequences, and is thus less readily perceived, than in vowel-nasal sequences like [aɳ]. Steriade thus argues that in textual examples like those cited by Whitney, the nasal was in fact pronounced as retroflex [ɳ], but was not being consistently recorded as such in the attested texts.[37]

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[37] Another possibility is that, for precisely the auditory-perceptual reasons that Steriade (1995b) mentions, the nasal in clusters like [gn] or [mn] did not consistently undergo the diachronic sound change that gave rise to the systematic distribution (and alternation) patterns observed in Vedic Sanskrit. This presupposes that diachronic sound change is a perceptually motivated (listener-based) phenomenon in the sense of Ohala (1981, 1989, 1993; cf. Blevins 2004, Hansson 2008a); see below for further suggestions along these lines.

Aside from the segmental opacity facts discussed so far, *n*-retroflexion is sometimes described as being sensitive to the right-hand context as well—that is, to what (if anything) follows the target nasal. The descriptive generalization appears to be that in order to undergo retroflexion, the /n/ must be followed by a non-liquid sonorant, effectively a vocoid). However, this appears to be not so much a restriction on *n*-retroflexion as such as a matter of the interaction of this process with other aspects of Sanskrit phonology, as shown convincingly by Schein & Steriade (1986).

As Schein & Steriade (1986) point out, the 'failure' of *n*-retroflexion to apply before continuants and liquids is only apparent. In the position before a (non-syllabic) continuant (/s ʂ ś h r/), an underlying nasal is realized as a nasalized vowel (the so-called *anusvāra*); this debuccalization prevents us from detecting any effects of *n*-retroflexion. As for the position before /l/, no relevant /n/+/l/ sequences seem to occur word-internally, making it impossible to determine if *n*-retroflexion would apply in that context or not. When such a sequence occurs across a word boundary (/…n#l…/), the /n/ cluster is realized as a nasal lateral—again, a process which bleeds *n*-retroflexion. This leaves only word-final position and nasal+stop clusters as environments where *n*-retroflexion can genuinely be said to fail, as shown in (38).

(38) Vedic Sanskrit: *n*-retroflexion only if /n/ is followed by a sonorant

a. No retroflexion in word-final position:
[brahman] (*[brahmaɳ]) 'brahman (VocSg)' (cf. LocSg [brahmaɳ-i])

b. No retroflexion before a stop:
[tr=n=t-te] (*[tr=ɳ=t-te]) 'split (3Pl middle)' (cf. 3Sg active [tr=ɳa=t-ti])

Schein & Steriade (1986) show that the restrictions in (38) can also be derived from independent generalizations about Sanskrit phonotactics. In (38a), retroflexion is overridden by the complete neutralization of nasals to [n] in word-final position, (cf. /a-gam/ → [agan] 'go (2Sg aorist)').[38] Similarly, (38b) can be attributed to the independent demands for place assimilation in nasal-stop clusters. In such clusters, if the stop is labial, palatal or dorsal, an /n/ is forced to assimilate to it, surfacing as [m], [ɲ] or [ŋ], respectively, and thus immune to retroflexion. When the stop is dental, as in (38b), it is reasonable to assume that the same assimilatory constraint is responsible for /n/ remaining dental [n] rather than becoming retroflex [ɳ]. Nasal-stop assimilation thus overrides *n*-retroflexion and prevents it from applying.[39]

The restriction that the target nasal must be followed by a (non-liquid) sonorant can thus be derived from the interaction of *n*-retroflexion with independently motivated aspects of Sanskrit phonology, and should not be viewed as a limitation on *n*-retroflexion as such. How-

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[38] In inflectional suffixes, word-final [m] is found (1Sg [-m], 3Du [-taːm], GenPl [-(n)aːm]).

[39] In nasals that are *underlyingly* retroflex, the requirement to preserve this input retroflex specification is sufficiently strong to force the following stop to yield instead: /ɳ/+/t/ → [ɳʈ], rather than [nt] (/pʰaɳ-ta/ → [pʰaɳʈa]).

ever, there is one such right-hand contextual restriction, which comes into play in those cases when *n*-retroflexion applies between the members of a compound word. Recall that *n*-retroflexion is always triggered by a retroflex continuant (/ʂ, r/) occurring earlier in the word. When there is also an /ʂ/ or /r/ *later* in the word, retroflexion fails to apply to the /n/ in the middle of the sequence {ʂ, r}…n…{ʂ, r}. Examples of this curious effect are shown in (39). The morphemes listed in (29b) frequently occur as the second member of a compound; their initial /n/ never undergoes *n*-retroflexion when preceded by a /ʂ/ or /r/.

(39) Retroflexion fails if target /n/ straddled by /ʂ, r/ 'triggers' (MacDonell 1910)

a.	praː-nr̩tyat	(*praː-ɳɽ̩tyat)	from -nr̩t- 'dance'	(cf. praː-ɳiti 'breathes')
	pari-nakʂati	(*pari-ɳakʂati)	'encompasses'	(cf. pari-hɳutaː 'denied')
b.	-niʂʈ^{h}aː-	(never *-ɳiʂʈ^{h}aː-)	'eminent'	
	-niʂʂid^{h}-	(never *-ɳiʂʂid^{h}-)	'gift'	
	-nirɳij-	(never *-ɳirɳij-)	'adornment'	
	-nrmɳa-	(never *-ɳrmɳa-)	'manhood'	

This rather striking property of *n*-retroflexion can be made sense of if it is interpreted from the perspective of listener-based sound change (Ohala 1981, 1989, 1993, Blevins 2004; see Hansson 2008a). Sanskrit *n*-retroflexion is most likely due to a *hypocorrective* sound change in the sense of Ohala (1993). Due to the coarticulatory effects of the /ʂ/ or /r/ on surrounding segments, the listener perceives a certain amount of retroflexion on the nasal, but fails to correctly attribute this property to contextual influence (from the preceding /r/ or /ʂ/), parsing retroflexion instead as an (intended) property of the nasal itself. If this view of the diachronic origins of *n*-retroflexion is correct, then the failure of retroflexion in the contexts in (39) can be explained in the following way. When an [n] is simultaneously preceded and followed by a retroflex continuant, the listener has a much stronger reason to correctly attribute the perceived (coarticulatory) retroflexion to contextual influence from one (or both) of the surrounding retroflex segments. As a result, the listener is more likely to 'factor out' the retroflexion, and to parse the representation intended by the speaker as containing a *non*-retroflex [n].[40]

This concludes the description of the workings of Sanskrit *n*-retroflexion. Before addressing how these facts relate to the general question of segmental transparency vs. opacity

[40] Of course, one might attempt to 'explain away' this phenomenon as being due to inaccurate transcription, in the same way that Steriade (1995b) accounts for the apparent variability of *n*-retroflexion after non-coronal stops (see above). The idea would be that the /n/ in (39), was in fact being pronounced as retroflex [ɳ], but that scribes tended to render it in writing as unassimilated [n], attributing the retroflexion to the following /r/ or /ʂ/, instead of parsing it (correctly) as an inherent property of the nasal. Though possible in principle, this type of explanation is not very plausible (and unnecessarily convoluted) in this particular case.

in consonant harmony systems, the following section discusses how the opacity effect has been captured in phonological analyses. The focus will be on analyses couched in Optimality Theory, the alignment-based treatments developed by Gafos (1999 [1996]) and Ní Chiosáin & Padgett (1997).

3.2.3.2. Earlier Analyses of the Opacity Effect

Recall that all coronal consonants—dentals, retroflexes and palatals alike (aside from the glide /y/)—are opaque, in that they block the assimilation from applying in a /ʂ…n/ or /r…n/ sequence if they intervene between the triggering /ʂ, r/ and the target /n/. It is useful to break this into two separate issues: a) the opacity of dentals and palatals; and b) the opacity of retroflexes. In the former case, the opacity is quite clearly due to the inherent incompatibility of dental or palatal articulation (or feature specification) with the retroflexion property being transmitted from trigger to target. Gafos (1999) interprets [retroflex] as a setting of the gestural parameter Tongue-Tip Constriction Orientation (TTCO). Dentals are also specified for TTCO, as having a 'flat' tongue-tip orientation, whereas palatals require raising the tongue dorsum towards the palate. Each is articulatorily incompatible with a [retroflex] TTCO setting. In the case of dentals this is because of their contradictory TTCO specification; in palatals, the conflict is with the specification of a different gestural parameter (expressed by Gafos 1999:224 in the form of an undominated constraint *[Tip-Blade: TTCO={retroflex}, Dorsum: CD={closed, critical}], where 'CD' stands for constriction degree).

As long as intervening dentals and palatals are required to maintain their input specifications, their articulatory incompatibility with retroflexion accounts for why they do not themselves undergo retroflexion. On the assumption that *n*-retroflexion is a matter of feature spreading (and thus gestural extension), this also explains why dentals and palatals block the spread of retroflexion: their articulation would necessarily interrupt the TTCO:[retroflex] gesture which is being extended. A crucial notion here is *contrast maintenance*, and both Gafos (1999 [1996]) and Ní Chiosáin & Padgett (1997) account for the opacity of intervening dentals in precisely these terms, the former appealing to Input-Output faithfulness constraints (FAITH(TTCO)), the latter invoking a constraint CONTRAST(RETR) which demands the presence of a surface retroflexion contrast. In both cases, the susceptibility of dental *nasals* to retroflexion is achieved by differentiating between low-ranked FAITH(TTCO, Nasal) and higher-ranked FAITH(TTCO, Obstruent)—and similarly for the CONTRAST(RETR) constraints of Ní Chiosáin & Padgett (1997).

In this way, the opacity of palatals and dentals (other than /n/) is straightforwardly accounted for in a spreading-based analysis where strict (articulatory) locality is maintained. The opacity of *retroflex* consonants, however, as well as the non-iterativity of the retroflexion process (see (27) above), requires additional consideration. In earlier generative analyses, the standard explanation for the fact that only the first nasal undergoes retroflexion in examples like /pra-ninaːya/ → [pra-ɳinaːya] was that this non-iterativity results from [ɳ] not being a retroflexion trigger. The preceding /r/ triggers retroflexion of the nearest /n/, which thus becomes [ɳ], but this nasal does not in turn ‘pass on’ the retroflexion feature/gesture to the next /n/, because retroflexion only spreads from continuants. The same explanation is provided by Gafos (1999), whose Optimality Theory analysis is cast in terms of the alignment of features/gestures to domain edges. For Gafos, *n*-retroflexion is driven by a constraint ALIGN-R(TTCO={retroflex}, trigger=[+cont]), which requires that the retroflexion gesture of a [ʂ] or [r] extend (temporally) to the right edge of the word—or, failing that, as far *toward* that word edge as possible.[41]

However, as Ní Chiosáin & Padgett (1997) point out, this traditional idea—that the first nasal blocks spreading because [ɳ] is not itself a trigger for spreading—crucially presupposes the *serial* application of phonological processes (rules). As such it cannot be incorporated directly into an output-oriented framework such as OT. The alignment-based analysis sketched by Gafos (1999) wrongly predicts that a /ʂ…n…n…/ sequence will surface as *[ʂ…ɳ…ɳ…]. The ALIGN-R(TTCO) constraint merely requires that the TTCO:[retroflex] gesture be spread as far toward the end of the word as possible; since any /n/ is in principle an undergoer (given that FAITH(TTCO, Nasal) is relatively low-ranked), the retroflexion gesture will spread up to—and potentially beyond—the *second* /n/ in the sequence. Note that there is only one trigger in this case: the /ʂ/ at the beginning of the sequence. The spreading property is not being passed on from left to right in ‘bucket-brigade’ fashion (that is, from /ʂ/ to the first nasal, and then from the first nasal to the second), the way earlier derivational analyses inherently assumed. In the alignment-based analysis, the optimal output arrangement is for the retroflexion gesture to extend from the triggering /ʂ/ to both nasals (and to any subsequent vowels and non-coronal consonants as well). The fact that /ɳ/, like other non-continuant retroflexes, does not itself constitute a trigger for retroflexion spreading is entirely beside the point.

Though Ní Chiosáin & Padgett (1997) do not discuss this explicitly, the same problem applies to the opaque behavior of intervening retroflex stops, /ʈ ʈʰ ɖ ɖʰ/. In an alignment analysis, there is no reason why the TTCO:[retroflex] gesture should not spread/extend through such a stop (/ʂ…ɖ…n…/ → [ʂ…ɖ…ɳ…]), since the intervening stop is not incompatible with the spreading gesture in the way a dental or palatal stop would be. If we indicate the temporal span of the retroflexion gesture with [ ]$_R$, following Ní Chiosáin & Padgett (1997), there is no immediately apparent reason why the ALIGN(TTCO) constraint should not force underlying /CVʂVɖVnV/ to surface as *CV[ʂVɖVɳV]$_R$ rather than as CV[ʂVɖ]$_R$VnV. Again, the fact that /ɖ/ would not otherwise (independently) trigger retroflexion spreading is irrelevant.

Ní Chiosáin & Padgett (1997) attempt to capture the non-iterativity facts by revising the original alignment-based analysis of Gafos (1999 [1996]). They propose that instead of align-

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[41] Though Gafos does not fully spell out the definition of his ‘HARMONY(TTCO)’ constraint in terms of ALIGN, it is quite clear from the context that this is what he has in mind (see esp. Gafos 1999:218).

ing to the right word-edge, the [retroflex] feature is instead required to align with a (following) *consonant*, as defined in (40):

(40) ALIGN-R([retroflex], C) (Ní Chiosáin & Padgett 1997)

Align any [retroflex] feature contained in a [+continuant] segment S_m to a consonant S_n, where $m < n$.

Given an input configuration like /ʂ…n…n…/ the constraint in (40) is fully satisfied by the candidate [ʂ…ɳ…n…], which is therefore able to emerge as the optimal output (preferred over less faithful *[ʂ…ɳ…ɳ…]). As regards the opacity of intervening /ʈ/ or /ɖ/, Ní Chiosáin & Padgett (1997) seem to attribute this to contrast maintenance (cf. their account of opacity in intervening dentals), but this is not stated explicitly. This can be illustrated with one of their tableaux, shown in (41). The analysis is cast in terms of Dispersion Theory (Flemming 2002, 2004, Padgett 2003). The candidates being evaluated are thus inventories of (potentially) contrasting output structures, rather than particular Input-Output mappings; the '•' symbol denotes contrast.

(41) Sanskrit: opacity of dental and retroflex stops (Ní Chiosáin & Padgett 1997)

	$\text{CONTRAST}_{\text{Stop}}$ (RETR)	ALIGN-R(retro)	$\text{CONTRAST}_{\text{Nas}}$ (RETR)
a. ☞ k[ʂ̩]$_R$vedaːna • k[ʂ̩]$_R$veɖaːna		*	
b. k[ʂ̩veɖ]$_R$aːna	*!		
c. k[ʂ̩veɖaːɳ]$_R$a	*!		*

Ní Chiosáin & Padgett argue that (right-)aligning the [retroflex] feature with the medial stop (41b), or with the subsequent nasal (41c), will results in the obliteration of a (potential) /d/ : /ɖ/ contrast. This violates undominated $\text{CONTRAST}_{\text{Stop}}$(RET), and ALIGN-R(retroflex) therefore has no effect. The fact that spreading does occur through an intervening non-coronal like /b^h/ is attributed to the fact that the perceptual distance between non-retroflex b^h and retroflex [b^h]$_R$ is too small to sustain a contrast, and thus to satisfy $\text{CONTRAST}_{\text{Stop}}$(RET). Since that constraint cannot be satisfied, lower-ranked ALIGN is able to exert its influence, forcing [retroflex] to spread to the labial stop.[42]

[42] It appears that further assumptions need to be made to explain why [retroflex] spreads all the way *through* a non-coronal like /b^h/ to reach a following /n/ (in /…ʂ…b^h…n…/). All that ALIGN-R in (40) requires is for the [retroflex] feature to align to *some* following consonant. Why does spreading not stop at the labial, yielding *k[ʂ̩ub^h]$_R$aːna instead of k[ʂ̩ub^haːɳ]$_R$a? The former would be analogous to (41b), the latter to (41c); just as in (41), the latter ought to lose out on $\text{CONTRAST}_{\text{Nas}}$(RET). It seems necessary to build some further stipulation about

However, spreading need not entail the obliteration or impossibility of a surface dental vs. retroflex contrast. In their equivalent of (41), Ní Chiosáin & Padgett neglect to mention the candidate (inventory) {k[ʂ]$_R$vedaːna • k[ʂveɖaːɳ]$_R$a}; in terms of lexical representations, the former might correspond to hypothetical /kʂved-aːna/, the latter to /kʂveɖ-aːna/, just as with the (41a) pair). In other words, they omit the possibility that retroflex stops might be transparent while dentals (and palatals) are opaque. In this candidate, the dental vs. retroflex stop contrast is still maintained in the output, just as it is in (41a), and top-ranked CONTRAST$_{Cons}$(RET) is thus satisfied. As for ALIGN-R(retro), it is only violated by one of the two members of this 'micro-inventory', namely by k[ʂ]$_R$vedaːna but not its counterpart k[ʂveɖaːɳ]$_R$a. In (41a), by contrast, alignment is violated by each member of the output pair. It seems reasonable to assume that the alternative {k[ʂ]$_R$vedaːna • k[ʂveɖaːɳ]$_R$a} should fare better. In other words, it appears that the spreading-based analysis does not correctly predict the opacity of retroflex stops (unlike that of dentals and palatals), without some further additions or stipulations.

Recall the case of Mayak coronal harmony, described in §3.2.2 above, where a stem-final alveolar nasal /n/ does not trigger assimilation of a dental /t̪/ in a following suffix (i.e. /CVn-Vt̪/ surfaces intact), but where an alveolar stop /d/ does trigger assimilation *across* that very same alveolar nasal (/dVn-Vt̪/ → [ɗVn-Vt]). This is analogous to what should in principle be possible in Sanskrit: retroflex stops and nasals, while not harmony triggers in themselves, ought to be capable of allowing harmony (retroflexion spreading) to propagate through them. The fact that this does not happen in Sanskrit needs to be explicitly accounted for. Earlier serial analyses, making use of feature geometry and autosegmental spreading rules, were able to do this in a straightforward manner. To the best of my knowledge, the same result has yet to be replicated in output-oriented analyses within Optimality Theory.

3.2.3.3. Retroflexion Spreading vs. Consonant Harmony

As noted in the previous section, the opacity effects observed in Vedic Sanskrit *n*-retroflexion are not difficult to account for in principle (though it is as yet unclear how the opacity of retroflexes is best handled in OT terms). As such, these effects are analogous to ones in a wide variety of harmony systems, as outlined in §3.2.1 above. Even the opaque behavior of segments that themselves carry the spreading property (stops like /ʈ ɖ/ in the Sanskrit case) is not unheard of in the general typology of harmony systems. For example, high rounded vowels block rounding harmony in a number of Mongolian and Tungusic languages, such as the Eastern Mongolian languages Halh (Khalkha), Buriat and Inner Mongolian (Shuluun Höh

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what is a legitimate target 'S_n' into the constraint definition of ALIGN-R in (40)—for example requiring that S_n must be capable of *perceptually* manifesting a [retroflex] articulation.

dialect), and the Tungusic languages Oroch, Ulcha and Even (Oxots dialect); see Kaun (1995).[43] This aspect of *n*-retroflexion is thus not particularly remarkable as such.

When we restrict ourselves to *consonant* harmony systems, however, segmental opacity effects are virtually unheard of, whereas they are commonplace in vowel harmony and vowel-consonant harmony systems. One of the central claims of this work (along with Rose & Walker 2004) is that consonant harmony is a phenomenon that is different in kind from these other types of harmony phenomena, and should be analyzed in terms of (long-distance) agreement rather than (local) spreading. On this view, which forms the basis of the formal analysis developed in chapters 4 and 5 (see also Walker 2000a, 2000c, 2001, Rose & Walker 2004), the absence of opacity effects—that is, the consistent *transparency* of intervening segments—is expected to be the norm rather than the exception. To the extent that an intervening segment does not enter into the agreement relation holding between the trigger-target consonant pair that straddles it, it will not interfere with the enforcement of that agreement, other things being equal.[44]

With respect to famous case of Vedic Sanskrit *n*-retroflexion, there is good reason to believe that it is *not* an instance of consonant harmony (in this sense of long-distance agreement). Rather, this phenomenon is a case of 'vowel-consonant harmony', akin to nasal harmony, pharyngealization harmony and the like. As such, *n*-retroflexion presumably *does* involve spreading, and the fact that it displays segmental opacity effects is therefore completely unsurprising. This is by no means a novel claim; after all, this is precisely what is assumed in works advocating strict (articulatory) locality in spreading have claimed (Ní Chiosáin & Padgett 1997, Gafos 1999). The crucial difference is that these works have assumed that *other* cases categorized as 'coronal harmony'—such as the sibilant harmony of Chumash, Tahltan or Navajo—also involve (local) spreading in the same way. Here the latter are claimed to be fundamentally different in kind from spreading phenomena.

Among the numerous consonant harmony cases surveyed in this work, Vedic Sanskrit *n*-retroflexion stands out as anomalous in several different respects. Most striking of these is the fact that the class of harmony targets (/n/) is distinct from that of harmony triggers (/ʂ, r̥/). This is otherwise completely unheard of in consonant harmony systems, where the generalization instead seems to be that the more similar two consonants are, the more likely they are to be subject to harmony (agreement) in the feature [±F]. Indeed, this sensitivity to similarity is a fundamental aspect of the correspondence-based agreement analysis developed in later chapters (cf. Walker 2000a, 2000c, 2001, Rose & Walker 2004); see §4.2.1.1 in particular,

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[43] In the Tungusic languages mentioned here, all high vowels are opaque, unrounded as well as rounded ones. In the Eastern Mongolian languages, by contrast, only high rounded vowels are opaque, whereas high unrounded vowels are transparent.

[44] Other things are not always equal, however. Hansson (2006a, 2007a, 2007b) demonstrates how, even with long-distance agreement, segmental opacity can arise as a by-product of constraint interaction in a number of ways (cf. Rhodes 2008 on opacity in Mongolian rounding harmony).

and §6.1 for related discussion. The implication is that if a sibilant like /ʂ/ triggers 'agreement' in a nasal like /n/, it should also trigger harmony in another sibilant, such as /s/, since a /ʂ/-/s/ pair is indisputably more similar than /ʂ/-/n/. The one case that violates this strong empirical generalization is Sanskrit *n*-retroflexion.[45]

Another somewhat peculiar property of this case is the perseveratory (progressive) directionality of assimilation. As discussed in §3.1, the default directionality for consonant harmony is anticipatory. When perseveratory harmony occurs, this is always an epiphenomenon of other factors, primarily morphological constituent structure (stem control). Vedic Sanskrit *n*-retroflexion violates this generalization: its directionality is consistently left-to-right, regardless of the morphological makeup of the form in question, and regardless of where in the word the triggering /ʂ, r/ or the target /n/ are located. By contrast, the observed directionality is unsurprising when considered as an instance of vowel-consonant harmony. For example, there are numerous cases of nasal harmony (Walker 2000b) where nasalization spreads consistently rightward, without this being attributable to constituency relations.

A third notable anomaly of Vedic Sanskrit *n*-retroflexion as a case of consonant harmony is the fact that it may (occasionally) cross a word boundary (i.e. applying in 'external sandhi'). Although this is not very common cross-linguistically, it does occur in some vowel harmony systems. For example, vowel harmony may apply between a clitic and its host (e.g. in Pasiego Spanish; McCarthy 1984, Vago 1988, Hualde 1989). In consonant harmony, this is completely unattested. If anything, consonant harmony conversely tends to hold within relatively restrictive morphological domains; it never reaches beyond the confines of the word. Again, the Sanskrit phenomenon would be the sole exception to a strong cross-linguistic generalization.[46]

To sum up, the presence of segmental opacity effects is merely one of a whole series of properties of Vedic Sanskrit *n*-retroflexion which are otherwise either unattested or extremely rare in the typology of consonant harmony. The most important ones are summarized in (42).

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[45] Others have made convincing arguments for why it should be precisely the continuants /ʂ, r/ that trigger retroflexion spreading, and why /n/ should be a more susceptible target than other dentals (Steriade 1995b, Ní Chiosáin & Padgett 1997, Gafos 1999). I should emphasize that I do not disagree with these in any way; the relevant point is that in other cases of long-distance consonant assimilation—which are here claimed *not* to involve spreading at all—disjoint trigger vs. target classes do not occur.

[46] Other properties could be mentioned here as well, but may ultimately be related to the opacity effects and/or the disjoint sets of triggers and targets. For example, consonant harmony always applies to any and all potential target consonants within its domain of application. Non-iterative application, such that only the *nearest* potential target consonant is affected, while subsequent targets are left untouched, is completely unheard of. Once again, Vedic Sanskrit *n*-retroflexion would be the sole exception.

(42) Vedic Sanskrit *n*-retroflexion as consonant harmony: typological anomalies

a. Segmental opacity:
For a particular class of segments to block the propagation of harmony is virtually unattested in consonant harmony systems.

b. Harmony triggers vs. targets:
In no other consonant harmony system is the set of triggers disjoint with that of targets; consonant harmony always respects relative similarity.

c. Directionality:
Perseveratory directionality which does not emerge from constituent structure (or other faithfulness effects) is otherwise unattested (or at best extremely rare; see §5.3.3) in consonant harmony systems.

d. Harmony domain:
In no other consonant harmony system does the assimilation apply at a phrasal (or clitic-group) level, reaching across word boundaries.

There is thus ample reason to be skeptical of the inclusion of Vedic Sanskrit *n*-retroflexion in the same category as the consonant harmony phenomena surveyed in this work. This particular case does indeed appear to involve feature spreading, and is thus analogous to vowel harmony and vowel-consonant harmony phenomena. Note that it is not self-evident that the Sanskrit case even fits the working definition of consonant harmony in §1.1 above, which is repeated in (43).

(43) Consonant harmony (definition):

Any assimilatory effect of one consonant on another consonant, or assimilatory co-occurrence restriction holding between two consonants, where:

a. the two consonants can be separated by a string of segmental material consisting of at the very least a vowel; and

b. intervening segments, in particular vowels, are *not audibly affected* by the assimilating property.

As discussed in §1.1, the limitation clause in (43b) is essential, in order to separate the phenomena under consideration from vowel-consonant harmony phenomena such as those involving the (unbounded) spreading of nasalization or pharyngealization. Thus, for example, a hypothetical interaction like /mawala/ → [mawana] (nasal consonant harmony) fits the definition in (43), whereas something like /mawala/ → [mãw̃ãnã] (nasal harmony) does not.

Note further that genuine coronal harmony phenomena, such as sibilant harmony, do fit the definition in (43) to the extent that it is true that intervening vowels and consonants are not *audibly* affected. While Gafos' (1999) analysis of such phenomena as involving strictly-local feature spreading (gestural extension) is based on the idea that these intervening segments are articulatorily affected, this 'permeation' of intervening vowels and non-coronal consonants by that articulatory setting is explicitly assumed to have minimal acoustic-auditory consequences. In any case, no descriptive (or other) sources on languages with coronal harmony systems explicitly describe intervening segments as being (audibly) affected. The phrasing in (43b) was explicitly tailored so as to include these cases, simply on the pragmatic grounds that the intervening segments might well be genuinely transparent.

The Sanskrit case is somewhat unique in this respect. It is an extinct language of antiquity, and our knowledge of its phonology derives from written texts, rather than from descriptions (or transcriptions) carried out by scholars trained in modern linguistic methods.[47] Under these circumstances, our transcriptions are to a great extent dependent on what distinctions happened to be made in the Sanskrit orthography. Retroflex articulation tends to have a considerable acoustic-auditory effects on vowel quality. Indeed, some languages have vowels that are inherently retroflex ('rhotacized', 'r-colored'), analogous to inherently nasalized vowels in many languages, and retroflex vowel harmony is attested (in Yurok; Robins 1958). In light of this fact, it is quite likely that the intervening vowels in a retroflexion span were affected by the spreading feature/gesture in a clearly audible way. If this was the case, then Vedic Sanskrit *n*-retroflexion would not strictly speaking satisfy the definition in (43)—no more so than a nasal harmony process where intervening vowels are audibly nasalized (cf. the /mawala/ → [mãw̃ãnã] example above). As noted by Gafos (1999), the Sanskrit process was interpreted along these lines already by Whitney (1889), who clearly assumes that retroflexion involves maintaining the retroflex posture of the tongue throughout the span from the triggering [ʂ] or [r] to the target [ɳ]. Allen (1951) suggests that the apparent long-distance (i.e. non-local) character of the retroflexion process may be illusory, as such an interpretation is based on the Sanskrit writing system, which is bound to be phonetically imprecise. Allen views retroflexion as a 'prosody' (in the Firthian sense), which is roughly comparable to a gestural span in the spreading-based analysis of Gafos (1999).

To sum up, we may safely conclude that Vedic Sanskrit *n*-retroflexion does involve (local) spreading, and that it is thus distinct from the other phenomena that are categorized as consonant harmony in this work. This accounts for the fact that it displays a series of properties that are otherwise unattested or extremely rare in the typology of consonant harmony. Sanskrit *n*-retroflexion is thus not to be equated with other cases of coronal harmony, such as sibilant harmony.[48] The two are distinct phenomena, in the same way as nasalization spread-

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[47] It is true that the linguistic tradition of ancient India is impressive, especially as regards phonetics. Nevertheless, ancient Sanskrit grammarians did not describe in detail the phonetic qualities of the intervening vowels in sequences like /…ʂub^{h}an…/ → […ʂu̠b^{h}a̠ɳ…].

[48] It is possible that certain other coronal harmony phenomena based on retroflexion are also cases of spreading rather than agreement. For example, some of the coronal stop harmonies (primarily in Australian and Dravidian languages) discussed by Steriade (1995b) and Gafos (1999) may well be of this type. In the absence of direct or circumstantial evidence bearing on the issue, this will have to remain an open question.

ing and nasal consonant harmony (e.g. in Sundanese and Yaka, respectively) are distinct. It is an unfortunate accident of history that the Sanskrit case has come to be one of the best-known (alleged) examples of 'coronal harmony' in the literature on theoretical phonology.

3.3. Interaction with Prosodic Structure

A further asymmetry between consonant harmony and other types of harmony pertains to the extent to which factors of prosodic structure can affect the application of harmony. Prosodic structure here refers to such notions as quantity (segmental length and/or syllable weight), stress (or lack thereof), and the parsing of segments into syllables, feet and other higher-level prosodic categories. In principle, prosody may exert its influence in a number of ways. Harmony may be bounded by a prosodic domain, such as the metrical foot, or prosodic properties may help determine the class of harmony triggers or that of eligible targets.

Sensitivity to prosodic factors is generally quite common in vowel harmony, as well as in vowel-consonant harmony processes. In light of this fact, it is all the more striking that prosody-sensitivity is entirely unattested in consonant harmony systems. Consonant harmony is never bounded by prosodic domains such as the syllable or the foot, and it is never sensitive to stress or quantity in any way.

Section §3.3.1 summarizes the ways in which harmony processes may be sensitive to aspects of prosodic structure. As none of these are attested for consonant harmony, this overview serves to illustrate just how widespread interactions with prosody are for harmony of other kinds. Yabem voicing harmony, an apparent counterexample to the claim that consonant harmony is never sensitive to prosodic factors, is discussed in §3.3.2. It is argued that this case does not involve prosody-sensitive *consonant* harmony as such (neither synchronically nor diachronically), and that it therefore does not invalidate the typological generalization.

3.3.1. Types of Prosody-Sensitivity in Harmony Systems

The different ways in which harmony systems may display sensitivity to prosodic factors are here grouped into three major categories: sensitivity to length, to syllable weight, and to stress (and metrical structure in general). It should be kept in mind that this tripartite categorization is somewhat fluid. Segmental length (§3.3.1.1) is intimately connected to syllable weight (§3.3.1.2), which is in turn frequently implicated in the assignment of stress and foot structure (§3.3.1.3). Because of the interdependence of these factors, it is sometimes difficult to tease them apart and determine which of them is the source for the observed interaction with harmony. It may well be that in all of the cases mentioned below, *stress* (or metrical structure in general) is ultimately responsible. The overview presented here takes a relatively agnostic perspective on this issue, categorizing individual cases in terms of the directly observed parameter, based on the descriptive sources consulted.

3.3.1.1. Phonological Length

The first factor under consideration is segmental length: the distinction between long and short vowels, and similarly between geminate and singleton consonants. At issue here is whether harmony can be dependent on the length (or shortness) of either the target or trigger segments. Such effects will be discussed in turn and each illustrated with attested examples. Sensitivity to length is not attested in consonant harmony, though it is frequently found in other types of harmony systems.[49]

An important caveat should be added. Differences in vowel length often go hand in hand with a difference in vowel quality, such as in height, 'tenseness' or centralization (or peripherality). It is quite possible that, in some apparent cases of long vs. short asymmetries in vowel harmony, it is the *quality* of the target (or trigger) vowel that is the crucial factor, not length. The asymmetry between long and short /e/ in Hungarian, mentioned below, is a case in point (where long [eː] is transparent while short [ɛ] is not). In some of the reported cases it is fairly obvious that this is the case, but descriptive sources do not always give detailed information about such relatively fine-grained (allophonic) differences in vowel quality.

It is quite common in vowel harmony systems for the length of the *target* vowel to play a role in determining whether (or how) that vowel is affected. Examples of this interplay between length and susceptibility to harmony fall into two categories. On the one hand, a long vowel may resist harmony while its short counterpart undergoes. Secondly, long vowels may conversely be targeted by harmony to the exclusion of their short counterparts. This interaction between length and susceptibility to harmony may either hold across the board, for all (relevant) long-short vowel pairs, or it may be limited to a specific pair of vowels.

There are numerous cases of the first type, where a long vowel is opaque (a non-undergoer) while the corresponding short vowel undergoes harmony. For example, Shahin (2002) describes pharyngealization harmony in Palestinian Arabic affects only short vowels, not long ones. In Telugu rounding harmony (Marantz 1980 *apud* Poser 1982, Kiparsky 1988; cf. also Venkateswara Sastry 1994), only short /i, u/ are undergoers, whereas all long vowels appear to be opaque. Other systems where the target vowel is required to be short include rounding harmony in various dialects of Maltese (Puech 1978, McCarthy 1985), suffix raising harmony in Lhasa Tibetan (Chang & Shefts 1964, Miller 1966), the lowering and front/back harmonies of Tigre (Palmer 1956, 1962, McCarthy 1985), and /a/-raising in Woleaian (Sohn 1971, 1975). This type of sensitivity to target-vowel length is illustrated for Palestinian Arabic in (44); following Shahin (2002), pharyngealization or postvelar articulation is marked on consonants with the IPA retraction symbol [̠].

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[49] As discussed in §3.2.2 above, the 'length' of the string of segments intervening between trigger and target can be relevant; this is clearly a different issue than segmental length, and will thus be ignored here.

(44) Pharyngealization harmony in Palestinian Arabic (Shahin 2002)[50]

a.	/ʕUlÆ/	[ˈʕʊ.lə]	‘Hiba’ (proper name)
b.	/ʁInIm-Æ/	[ˈʁɪ.nɪ.mə]	‘goat’
c.	/s̞E:f-E:n/	[s̞ɛ.ˈf̞e:n]	‘summers (Du)’
d.	/t-s̞I:b-I-ʃ/	[ʔ̞ɪt̞.s̞ɪ.ˈb̞i:ʃ]	‘don’t touch (it)! (2SgFem)’
e.	/n-s̞I:b/	[n̞.s̞i:b]	‘should we touch (it)?’

The short vowels in (44a–b) are pharyngealized (retracted and lowered), due to the word-initial consonant. (The status of word-final schwa is complicated, but can be ignored for the present purposes). In (44c), retraction, triggered by pharyngealized /s̞/ only affects the short vowel of the first syllable, not the long vowel in the following syllable; note that both vowels are long in the input representation. The (44d–e) examples show even more clearly that it is surface rather than underlying vowel length that is relevant; both forms contain the stem /-s̞I:b-/. In (44d) the root vowel surfaces as short, and thus undergoes pharyngealization harmony, whereas the following suffix vowel fails to undergo harmony because it is long on the surface. In (44e) the length of the root vowel is preserved on the surface; as a result, it fails to harmonize.

Sensitivity to vowel length in the Palestinian Arabic case in (44) is across-the-board: all long vowels fail to undergo harmony. The more idiosyncratic type of length-sensitive harmony is exemplified by languages like Wolof (Ka 1988). In Wolof tongue-root vowel harmony, it is only with respect to the low vowel /a/ that length plays a role. Whereas short /a/ undergoes [ATR] harmony regularly, long /a:/ is opaque, being consistently [–ATR] (or [RTR]; see Pulleyblank 1996).

In the systems discussed thus far, long vowels fail to undergo harmony. It is considerably rarer for harmony to preferentially target long vowels while failing to affect their short counterparts. One reported case is Menominee (Menomini; Bloomfield 1962, 1975, Cole 1991, Cole & Trigo 1988, Archangeli & Pulleyblank 1994, Milligan 2000). As originally described by Bloomfield, Menominee vowel harmony consists in the *long* mid vowels /e:, o:/ raising to high under the influence of a subsequent high vowel, whereas short /e, o/ are unaffected (and transparent, along with /a, a:/).[51] Another case where the target is required to be a long vowel is Buriat rounding harmony (Poppe 1965, Kaun 1995). Short /u/ triggers rounding harmony on a vowel in the following syllable, but only when the latter is long; contrast (45a) with (45b).

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[50] I depart from Shahin’s (2002) practice of displaying *surface phonological* representations with ‘{ }’, as distinct from *phonetic* forms in ‘[ ]’, though I agree that the two are in principle separate notions.

[51] Milligan (2000) argues that the traditional description is incorrect, and that Menominee harmony in fact targets all mid vowels, not just those that are long.

(45) Rounding harmony in Buriat (Poppe 1965 *apud* Kaun 1995)

a.	/xul-dEː/	xul-doː	'foot (refl. dat.)'
b.	/xul-dE/	xul-de	'foot (dat.)'
c.	/xuzuːn-dEː/	xuzuːn-deː	'neck (refl. dat.)'
d.	/xuzuːn-dE/	xuzuːn-de	'neck (dat.)'

The forms in (45d–e) illustrate a further restriction on Buriat rounding harmony: it is only triggered by short /u/, not by long /uː/. This is an example of the second main type of length-dependence in harmony systems, whereby the length of the harmony *trigger* is a factor. This appears to be a somewhat less common state of affairs. Again, the restriction can go both ways: in some systems only long vowels trigger harmony, in others only short vowels do. As we see in (45), Buriat is an example of the latter type. According to Poppe (1960), rounding harmony is only triggered by short (and [+ATR]) /u/, but not by long /uː/ (nor the [–ATR] vowels /ʊ, ʊː/). Another example is rounding harmony in Maltese (Standard and Mellieħa dialects; Puech 1978), where a suffix /e/ rounds (and backs) to [o] due to harmony from a rounded vowel in the preceding syllable. This harmony is triggered by short rounded vowels, as shown in (46) for Standard Maltese.[52] To highlight where harmony applies vs. fails, the relevant (potential) trigger-target pairs are underlined.

(46) Rounding harmony in Standard Maltese (Puech 1978)

a.	/kitib-l-ek/	kitib-l-ek	'he wrote to you'
	/kitib-om-l-ok/	kitib-óm-l-ok	'he wrote them to you'
b.	/kitib-uː-l-ek/	kitib-úː-l-ek	'he wrote yo you'
	/n-buːs-ek/	n-búːs-ek	'I kiss you'
c.	/ma kitib-uː-l-ek-ʃ/	ma kitib-u-l-ék-ʃ	'I do not write it to you'
	/ma n-buːs-ek-ʃ/	ma n-bus-ék-ʃ	'I do not kiss you'

Short /u, o/ trigger harmony (/-ek/ → [-ok]; 36a), but long /uː/ does not (46b). As can be seen from the examples in (46c), it is underlying rather than surface length which matters in this particular case. When an underlyingly long vowel surfaces as short (due to stress shift, and unstressed vowel shortening), it still fails to trigger rounding harmony on a following vowel.

At first glance, Hungarian backness harmony (Ringen & Vago 1998, Siptár & Törkenczy 2007) seems to involve a similar pattern, with respect to the behavior of short /e/ vs. long /eː/, but this is better understood in terms of vowel quality rather than quantity. In Hungarian, long /eː/ is transparent (as are /i, iː/), in that it allows [+back] harmony to propagate across it. Short /e/, by contrast, behaves for the most part as a harmonic vowel: a legitimate trigger of front harmony, and is generally *not* transparent (that is, it is typically a target for back harmony). However, the two vowels are quite distinct phonetically, short [ɛ] vs. long [eː], and this is

[52] In the Mellieħa dialect, the target vowel is likewise required to be short.

probably the reason for their different harmony behavior. As argued by Ringen & Kontra (1989), there is a gradient of 'harmonicity' (vs. neutrality/transparency) along the scale [iː]-[ɪ]-[eː]-[ɛ], with long /eː/ showing a weak tendency towards behaving as a front harmonic vowel, but in a much more limited way than short /e/ (= [ɛ]).

The reverse pattern, whereby long vowels are favored as harmony triggers, is also attested, though less robustly so. In Tigre front/back harmony, short vowels ([ə, ɐ]) always agree in backness with a following long vowel (Palmer 1962, McCarthy 1985). The triggering long vowel imposes its [±back] value on any and all preceding short vowels. However, since the only vowels that are contrastively specified for [±back] in the first place are long vowels, it is not necessary to interpret the harmony as being sensitive to length. A similar restatement would work for Tigre lowering harmony as well (Palmer 1956), by which short [ɐ] becomes fully low before the long low vowel [aː]. Since there is no independently existing short [a], the length condition on the trigger would seem to be superfluous.

A second possible case of harmony where the trigger is required to be long is Old Norwegian (Hagland 1978, Majors 1998). Aside from the fact that Old Norwegian vowel harmony is also sensitive to *stress*, there appears to be a restriction such that a long (and stressed) /aː/ forces the vowel of a following (unstressed) syllable to be mid rather than high. The examples in (47) are given in pseudo-orthographic representation:

(47) Height harmony in Old Norwegian (Hagland 1978)

a.	ˈvaːr-er	'our (NPlMasc)'
	ˈlæːr-d-er	'learned (NPlMasc)'
	ˈmæːl-t-o	'said (3Pl)'
b.	ˈadr-um	'other (DSgMasc)'
	ˈæll-u	'all (DSgNeut)'
	ˈæll-er	'all (NPlMasc)'

As evidenced by the forms in (47b), the short low vowels /a, æ/ failed to trigger harmony, and could thus be followed by either high or mid vowels. However, this case can be viewed as vowel *reduction* rather than length-sensitive vowel harmony. Hagland (1978) and Majors (1998) interpret the restriction observed in (47a) as being due to the neutralization of high and mid vowels in those final syllables that are not parsed into the same (bimoraic) foot as the preceding stressed vowel.

In sum, many harmony systems are sensitive to the length of either the trigger or the target. Harmony may be triggered by short vowels but not long ones, or by long vowels but not short ones (though the latter is not as firmly attested). Likewise, harmony may target long vowels but not short ones, or short vowels but not long ones. In such cases, the non-undergoers (be they short or long) are neutral, and are either opaque—blocking the propagation of harmony—or, occasionally, transparent. Note that although length-sensitivity is attested for vowel harmony and vowel-consonant harmony alike (recall Palestinian Arabic pharyngealization in (44)), it is always *vowel* length that is the crucial factor, not the geminate/singleton distinction among consonants. It is thus perhaps not too surprising that consonant harmony systems are never sensitive to whether the trigger or target consonant is short (singleton) or long (geminate). Nevertheless, it should be emphasized that the strictly-local-spreading approach to consonant harmony (see §1.2.3 and §4.1.1) treats intervening vowels as targets—that is, as undergoers—no less than consonants. There is thus no principled reason why consonant harmony could not, for example, be blocked by an intervening long vowel (perhaps all long vowels) while being enforced across short vowels.

3.3.1.2. Syllable Weight

In the cases mentioned in §3.3.1.1, harmony systems of various kinds were seen to be sensitive to vowel length. Since vowel length is directly correlated with syllable weight, in that a vowel length renders a syllable *heavy* (bimoraic), it is conceivable that weight, rather than segmental length as such, is the relevant factor in some of these systems. If syllable weight as such is able to interact with harmony, one would expect vowel harmony systems to exist in which a short vowel is required to be in a closed syllable (or, conversely, in an open syllable) in order to function as a trigger—or, alternatively, as a target—of harmony.

There appear to be extremely few examples of vowel harmony being sensitive to syllable weight in this obvious fashion. The best candidate known to me is a historical sound change in Sinhalese (Geiger 1938, Bright 1966), whereby the back vowels /u, o, a/ have been fronted to [i, e, æ] under the influence of a front vowel in the following syllable. This only took place if the target vowel was in a heavy syllable; that is, when /u, o, a/ were either long or in a closed syllable. However, just as in the case of length-sensitive harmony, it is always conceivable that the crucial factor here was *stress* (i.e. foot structure), which is very often sensitive to syllable weight.

Another possible case of this type is pharyngealization harmony in Cairene Arabic (see Hoberman 1989 and references therein). In this language, [+RTR] is a property characterizing entire syllables, rather than individual segments. Rightward spreading of [+RTR] to subsequent syllables is only triggered by a closed syllable (and the *target* syllable is furthermore required to contain a low vowel). The fact that the relevant criterion seems to be a 'closed' rather than 'heavy' syllable raises some suspicion. The conditioning environment might then perhaps be restated as C.C__, where C_1 belongs to a [+RTR] syllable and C_2 does not. It would then be possible to derive the rightward 'harmony' by the interaction of independent constraints: a) a demand that adjacent consonants agree in [±RTR]; b) that there be [±RTR] agreement throughout a syllable; and so forth. It is not even clear that the 'closed syllable' notion would necessarily figure in such an account, let alone syllable weight as such.

Yet another potential case, again involving reference to closed syllables, is suffix rounding harmony in Maltese (Puech 1978). In Standard Maltese (see (36) above), rounding harmony exclusively targets vowels in word-final closed syllables. The same restriction appears to hold for the 'unrounding' version of rounding harmony in the Qormi and Siggiewi dialects:

an unrounded vowel triggers unrounding of an (underlyingly rounded) suffix vowel in the following syllable, but only if the latter is in a word-final closed syllable. This is evident from the fact that Puech (1978) states the right-hand environment for the relevant harmony rules as $\_\_C_1\#$. For Standard Maltese, Puech (1978) explicitly states that it is only 'a final I in a closed syllable' that undergoes rounding harmony to [o] when preceded by another [o] (Puech's 'I' = short [i]~[e]). However, it is not clear whether a word-final vowel in an open syllable (i.e. in absolute word-final position) fails to undergo harmony due to its being in an *open* syllable, or for some other reason. Recall from above that Standard Maltese rounding harmony applies only to underlyingly short vowels. As Puech (1978) notes, all vowels that can occur in absolute final position happen to be underlyingly long (even though they surface as short); this alone would make them exempt from harmony. It is therefore by no means obvious that the closed vs. open syllable distinction as such is relevant.[53]

The general conclusion is that there is very little conclusive evidence that harmony systems can make direct reference to, or be directly dependent on, the distinction between light and heavy syllables. This implies that mora count is directly relevant to harmony processes only as a property of individual *segments*, not syllables. In addition, mora count can figure indirectly, by the harmony being sensitive to foot structure, which in turn is partly determined by weight relations among syllables.

3.3.1.3. Stress and Metrical Structure

There is no doubt that stress and related metrical notions (e.g. foot structure) can exert an influence on harmony processes. This appears to be considerably more common than direct sensitivity to segmental length (or syllable weight). Majors (1998) surveys stress-dependent vowel harmony systems; the reader is referred to that study for more detailed discussion of several of the individual cases mentioned below. Since stress-sensitivity is fairly common, the brief overview below is quite limited and sketchy.

The ways in which stress can factor into the workings of individual harmony systems fall into three broad classes, each of which will here be considered separately. Stress may act as a *trigger* condition, such that a triggering vowel is either required to be stressed or unstressed. Alternatively, there may be a requirement that a *target* vowel be stressed or unstressed. Finally, stress may also have a purely delimiting or bounding function, such that harmony does not spread past a stressed vowel, or that harmony holds only within the foot but not across a foot boundary.

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[53] Alternatively, the restriction may be 'string-based', rather than sensitive to syllable weight or syllable structure, in the sense that the target vowel is required to be flanked by consonants. Consider the case of Nawuri (Casali 1995), where centralization targets underlyingly short front vowels in 'inter-consonantal' position specifically—that is, everywhere but in absolute initial or final position.

It is very common for vowel harmony to be triggered only by a stressed vowel, such that the harmonic feature spreads onto an unstressed vowel (or an entire span of unstressed vowels) in nearby syllables. Examples of this include height harmony in the Pasiego and Tudanca dialects of Spanish (Penny 1969a, 1969b, 1978, McCarthy 1984, Vago 1988, Hualde 1989, Flemming 1994), suffix-induced height harmony in Lhasa Tibetan (Sprigg 1961, Chang & Shefts 1964, Miller 1966), height harmony in Old Norwegian (Flom 1934, Hagland 1978), backness and rounding harmony in Eastern Mari (Cheremis; Hayes 1985, Flemming 1994), and height harmony among mid vowels in Breton (Falc'hun 1951, Anderson 1974).

The requirement that the harmony trigger be a stressed vowel is also attested for vowel-consonant harmony. For example, in the Applecross dialect of Scottish Gaelic, nasalization spreads rightward from a stressed nasalized vowel to segments in subsequent unstressed syllables in the word, unless blocked by a stop or one of the mid vowels /e, o, ə/ (Ternes 1973, van der Hulst & Smith 1982), as illustrated in (48).[54] Note that stress typically falls on the root-initial syllable. In (48b), nasal harmony is blocked by a stop, in (38c) by a mid vowel.

(48) Nasal harmony in Applecross Gaelic (van der Hulst & Smith 1982)

a.	/ʃέnɛːvar/	ʃ̃ɛ̃́nɛ̃ːṽãr̃	'grandmother'
	/kʰɔ-vĩ́aːt/	kʰɔṽĩ́ãːt	'how much'
b.	/sŋã́nʲdʲan/	s̃ŋã́nʲdʲan	'thread'
	/kʰɔ̃́ispaxk/	kʰɔ̃́ĩs̃paxk	'wasp'
c.	/mã́ːriçən/	mã́ːr̃ĩç̃ən	'mothers'
	/sã́uɮəxkənʲ/	s̃ã́ũɮ̃əxkənʲ	'to compare'

Another well-known case of stress-sensitive nasal harmony is Guaraní (Gregores & Suárez 1967, Rivas 1975, van der Hulst & Smith 1982, Piggott 1992, Flemming 1994, Beckman 1998, Majors 1998, Walker 2000b). In Guaraní, nasalization spreads from a stressed nasalized vowel to unstressed syllables in both directions (with certain restrictions that are irrelevant here).

Harmony may also be sensitive to whether or not a potential *target* vowel is stressed or unstressed. This is frequently the case in those systems that are sometimes labelled 'umlaut' or 'metaphony', where a stressed vowel assimilates to a vowel in an adjacent unstressed syllable (usually the immediately following one). For extensive discussion of various cases of this type, see Dyck (1995) and Walker (2004, 2005).

One case where harmony exclusively targets the stressed vowel of the word is the metaphony found in various Asturian dialects of Spanish (Hualde 1989, 1998, Dyck 1995, Walker 2004, 2005, Finley 2009). In most cases, a word-final unstressed high vowel (typically /u/) triggers raising of a stressed non-high vowel, without any observable (or as yet documented)

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[54] Nasalization also spreads leftward to the onset consonant of the stressed syllable (that is, it spreads throughout the entire stressed syllable), but that need not concern us here.

effect on intervening vowels. In the Lena dialect, this raising takes the form of a vowel shift, merging /e, o/ with underlying /i, u/, and /a/ with (unraised) /e/. In the Alto Aller dialect, by contrast, no merger occurs, with /e, o, a/ raising to the intermediate allophonic values [ẹ, ọ, ɛ]. Finally, in the Nalón valley dialect, raised /e, o/ merge with /i, u/, whereas the raising of /a/ is allophonic, yielding [ɔ]. The examples in (49) are from the Lena dialect; the forms in (49b) illustrate the transparency of an intervening unstressed vowel.

(49) Metaphony in Lena (Asturian) dialect of Spanish (data from Hualde 1998)

a.	*nínu*	'boy'	cf. *nénos* 'boys', *néna* 'girl'
	tsúbu	'wolf'	cf. *tsóbos* 'wolves', *tsóba* 'she-wolf
	pélu	'stick'	cf. *pálos* 'sticks'
b.	*kéndanu*	'dry branch'	cf. *kándanos* 'dry branches'
	péʃaru	'bird'	cf. *páʃara* 'female bird'

There are also a great number of harmony systems which require the target vowel to be *unstressed* rather than stressed. However, it appears that such cases are more appropriately classified either as being bounded by stress (operating within the domain of the foot) or as being sensitive to the stressed vs. unstressed nature of the *trigger* rather than target vowel. When harmony spreads from a stressed vowel to a vowel in an adjacent syllable, it is virtually always the case that the latter is unstressed. Similarly, harmony which exclusively targets unstressed vowels will be blocked by an intervening stressed syllable. It is more appropriate to think of such a situation as a case of higher-level prosodic categories imposing a boundary on the spreading of the harmonic property. Flemming (1994) argues that all cases of stress-sensitivity can and should be reinterpreted as involving foot-bounding (or reference to higher-order metrical constituency in some other way). Flemming makes the strong claim that relative stress—in the sense of prominence relations (e.g. between the trigger and target vowels)—plays no role whatsoever in any assimilation processes, including harmony. Metrical structure, on the other hand, can condition assimilation by providing a bounding domain for feature spreading. This controversial issue is beyond the scope of the present study (see Beckman 1998 for an alternative view of some of the relevant cases).

As an example of potentially foot-bounded harmony, some Spanish dialects display a centralization (or [–ATR]) harmony which emanates from a word-final vowel and spreads leftward up to and including the stressed vowel. This is the case in the Tudanca dialect (Hualde 1989, Flemming 1994, Walker 2004, 2005), and also in the independently occurring [ATR] harmony of (Eastern) Andalusian dialects (at least according to Zubizarreta 1979).[55]

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[55] In the latter case, there is some controversy as to whether or not pretonic vowels are affected as well (see Hualde & Sanders 1995). Zubizarreta (1979) claims that stressed high vowels are transparent and allow the centralization feature to propagate further to the left. In Pasiego (Penny 1969a, 1969b, McCarthy 1984, Hualde 1989, Walker 2005, Finley 2009), a

Vowel-consonant harmony is also frequently bounded by stress. For example, Schourup (1972, 1973, citing David Stampe, pers. comm.) describes an unidentified Midwestern dialect of English as having a nasal harmony which spreads leftward from a coda nasal up to and including the stressed syllable. In a word like *rewiring*, only the pretonic syllable *re-* remains oral: [ri.ˈw̃ãĩ.r̃ĩŋ]. Another example of nasal harmony with similar characteristics is that of Guaraní, which was briefly mentioned above. Here nasalization spreads from a stressed vowel to unstressed vowels in both directions, but is blocked by a stressed syllable, as illustrated in (50). Note that under rightward spread (50b), nasalization is blocked by the stressed syllable as a whole, rather than by the stressed vowel as such, and hence does not affect the onset of that syllable. Interestingly, a prenasalized stop blocks rightward nasalization only if there is a stressed vowel somewhere further to the right, as the pair in (50c) shows.

(50) Nasal harmony in Guaraní (data from Walker 2000b)

a.	/ro-^{m}bo-porã́/	r̃õmõpõr̃ã́	'I embellished you'
	/^{n}do-roi-^{n}dupã́-i/	nõr̃õĩnũpã́ĩ	'I don't beat you'
b.	/irũ̀-ré/	ĩr̃ũ̀ré	'ex-friend'
	/akã̀raɣ^{w}é/	ãkã̀r̃ãɣ^{w}é	'hair (of the head)'
c.	/^{m}bẽ́^{n}da/	mẽ́nã	'husband'
	/^{m}bẽ̀^{n}da-ré/	mẽ̀^{n}daré	'widow(er)'

Other cases of vowel-consonant harmony show bounding effects of a similar kind. Progressive [RTR] harmony in Nɬeʔkepmxcin (Thompson River Salish; Thompson & Thompson 1992) is triggered by a root consonant or vowel specified as [+RTR], and targets any subsequent 'retractable' segments, up to and including a stressed (suffix) vowel. This is illustrated in (51), where the extent of the [+RTR] span is indicated with brackets; the root is marked with '√' in the input representation. Forms like (51b) suggest that the consonant immediately following the stressed vowel also falls within the harmony domain, even though it is strictly speaking not part of the stressed syllable.

(51) RTR harmony in Nɬeʔkepmxcin (Thompson & Thompson 1992)

a.	/ʔes-√ç̙ə̙m-eleʔ=xən/	ʔes[ç̙má]leʔxn	'he has feet smeared with dirt'
b.	/nə-√k'ə̙ɬ=us-n-t-es/	nk'[ɬós̙]es	'he smears the window'

To sum up, sensitivity to higher-level prosodic structure, such as stress and foot boundaries, is relatively common in vowel harmony and vowel-consonant harmony systems alike. In consonant harmony systems, on the other hand, such effects are unattested. The next section exam-

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dialect closely related to the Tudanca one, [ATR] harmony is not bounded by the foot; instead, it propagates to the very beginning of the phonological word, including proclitics and prepositions.

ines one apparent exception to this generalization, voicing harmony in Yabem, and explains how despite appearances, that case does not constitute an example of foot-bounded consonant harmony.

3.3.2. Yabem: An Apparent Case of Foot-Bounded Consonant Harmony

There exists one relatively well-documented case which at first glance seems to be a counter-example to the generalization stated earlier, that consonant harmony is never sensitive to prosodic factors. This is the foot-bounded obstruent voicing harmony that appears to obtain in Yabem, an Austronesian language of Papua New Guinea (Dempwolff 1939, Bradshaw 1979, Ross 1993, 1995, Hansson 2004b). In this and other related languages of the Huon Gulf chain, a phonological tone distinction (high vs. low) has developed, which is correlated historically with the voicing vs. voicelessness of neighboring consonants. Even synchronically, voicing and tone are intimately connected, and the nature of this interdependence makes Yabem rather unique (Poser 1981, Hansson 2004b). As we shall see below, the voicing agreement patterns that superficially obtain in Yabem are not due to 'harmony' of any sort but rather result from tone spreading and tone-voicing interaction.

As illustrated in (52), Yabem has a two-way tone contrast: every syllable carries either high or low tone. However, absolute minimal pairs are only possible when no obstruents are present (other than /s/; see below), as in (52a). This is due to the fact that in syllables containing stops, tone is correlated with voicing: in high-toned syllables, stops are voiceless, while in low-toned syllables, they are voiced (52b).

(52) Tone and obstruent voicing in Yabem morphemes (Ross 1993, 1995)

a. Minimal pairs without obstruents (other than /s/):

áwé	'outside'	àwè	'woman'
ólí	'body'	òlì	'wages'
jáó	'prohibition'	jàò	'enmity'
-sáʔ	'to hammer'	-sàʔ	'put on top of'

b. Minimal pairs containing (non-/s/) obstruents:

píŋ	'shell'	bìŋ	'speech'
típ	'all at once'	dìb	'thud'
pálíŋ	'careless'	bàlìŋ	'far away'
sákíŋ	'service'	sàgìŋ	'house partition'

The sole fricative in the Yabem inventory, /s/, is phonetically voiceless but co-occurs with both high and low tone. This is the result of a relatively recent merger of voiced */z/ (which occurred only in low-toned syllables) with voiceless /s/, which was originally found exclusively in high-toned syllables. Dempwolff (1939:7) describes /s/ as being somewhat voiced (‘etwas stimmhaft’) in low-toned syllables, though this does not seem to be true anymore, judging from the description by Ross (1995).

Note that in the examples in (52) above were uniformly high- or low-toned, even when disyllabic. The reason is that in Yabem words, the final two syllables form an iambic foot, and the syllables within this foot must agree in tone—and thereby also in obstruent voicing. When inflectional prefixes attach to monosyllabic roots, this results in harmony alternations: the prefix surfaces with high tone (and a voiceless stop, if any) before a high-toned root (53a), but with low tone (and a voiced stop) before a low-toned root (53b).

(53) Harmony alternations in verb prefixes: 1Sg /ka-/, 1InclPl /ta-/ (Ross 1995)

a. Before monosyllabic high-toned roots:

ká-táŋ	‘I weep’ (realis)	tá-táŋ	‘we weep’
ká-tɛ́ŋ	‘I ask’ (realis)	tá-tɛ́ŋ	‘we ask’

b. Before monosyllabic low-toned roots:

gà-dèŋ	‘I move toward’ (realis)	dà-dèŋ	‘we move toward’
gà-dɛ̀ŋ	‘I put (on shelf)’ (realis)	dà-dɛ̀ŋ	‘we put (on shelf)’

Beyond the confines of the word-final iambic foot, syllables are consistently high-toned. Consequently, the prefixes seen in (53) will surface with high tone—and a voiceless stop—when they attach to a disyllabic root, regardless of whether that root is high- or low-toned, as shown in (54).

(54) No harmony alternations outside the foot (Ross 1993, 1995)

a. Before disyllabic high-toned roots:

ká-létí	‘I run’ (realis)
ká-kátɔ́ŋ	‘I make a heap’ (realis)

b. Before disyllabic low-toned roots:

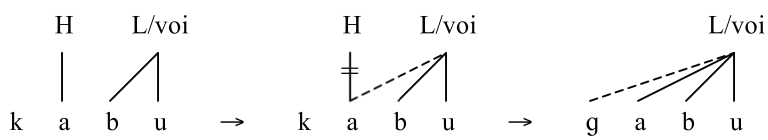
ká-dàbìŋ	‘I approach’ (realis)
ká-gàb^{w}àʔ	‘I untie’ (realis)
ká-dàm^{w}è	‘I lick’ (realis)
ká-màdòm	‘I break in two’ (realis)

If we leave tone aside and consider only obstruent voicing, Yabem could be characterized as enforcing obstruent voicing harmony within the foot, but not across a foot boundary. On this view, stops are required to agree in voicing, with affixes harmonizing to roots (just as in Kera voicing harmony; see §3.1.2 above)—but only if the stops belong to the same *prosodic* constituent, namely the metrical foot.

While this characterization does observational justice to the facts, there is no need to assume that Yabem has voicing harmony at all. As noted above, obstruent voicing and tone are interdependent. To be more precise, *tone* is the property which is independently contrastive (unpredictable) in Yabem—as evidenced by minimal pairs such as those in (52a) above. Wherever stops occur, their voicing or voicelessness is always predictable from the tone of the syllable in question. For this reason, Yabem must be viewed as having a foot-bounded *tone spreading* process (‘tone harmony’), combined with tone-induced voicing in stops, rather than a foot-bounded obstruent voicing harmony as such. The closely related language Bukawa also has foot-bounded tone spreading of the same kind as in Yabem, but without voicing being dependent on tone (Ross 1993).[56] In other words, in (53) it is only the *tone* alternations in prefix syllables that are due to any sort of ‘harmony’ with the following root. The concomitant voicing alternations simply fall out from the allophonic distribution of [±voice] values: stops are realized as voiced in low-toned syllables but as voiceless in high-toned syllables (Poser 1981, Hansson 2004b).

An interesting alternative is proposed by Bradshaw (1999), who argues for a multiplanar (feature-geometric) treatment of tone-voicing interactions. Bradshaw suggests that the traditional feature [voice] and low tone (L) should be replaced by a single privative feature she refers to as [L/voice], which can be associated either subsegmentally (to the Laryngeal node) or prosodically (to the mora). In the former case, the phonetic manifestation of the [L/voice] feature is voicing, whereas in the latter case it is low tone. This treatment allows the Yabem interaction to be captured in terms of the (foot-bounded) autosegmental spreading of [L/voice] to consonants and vowels (i.e. syllable nuclei) alike. For example, Bradshaw spells out the derivation of /ká-bù/ → [gàbù] ‘I insult (realis)’ as follows:

(55) Tone/voice harmony in Yabem (Bradshaw 1999)



In the first step of the derivation in (55), [L/voice] spreads to the mora of the prefix syllable. In the second step, it spreads to (the Laryngeal node of) the initial /k/. The same regressive spreading process is responsible for both tone and voicing within the foot.

When reinterpreted in the manner Bradshaw (1999) suggests—and this is independent of the particular feature geometry she proposes—the Yabem pattern is more akin to vowel-consonant harmony phenomena, such as the spreading of nasalization, pharyngealization, or retroflexion (as in Sanskrit, cf. §3.2.3 above). Here, just as in those cases, a single property would spreading throughout a particular domain, affecting all segments within its scope, vowels as well as consonants. In this context, the foot-bounded character of Yabem

[56] It appears that voicing was once dependent on tone in Bukawa as well, but that this dependence has been lost. In the word-final syllable (the head of the iambic foot), onset stops are voiceless, but in the penultimate syllable (the non-head), onset stops are voiced. See Ross (1993) for further discussion.

tone/voicing harmony would not be surprising at all; as we saw in the previous section, vowel-consonant harmony is frequently sensitive to metrical structure, stress, and the like. However, Bradshaw (1999) does not provide a full account of the Yabem system; there is a range of issues which her proposal does not attempt to address (see Hansson 2004b), such as the neutrality (and transparency!) of /s/ to [L/voice] spreading, or the predictability of voicing in obstruents vs. contrastivity of tone in vowels. A full constraint-based analysis is laid out in Hansson (2004b), which is not based on any particular representational assumptions but rather encodes tone-voicing interaction in the form of an implicational markedness constraint.

Having dismissed Yabem as a synchronic case of foot-bounded consonant harmony, we must still consider the possibility that the *diachronic* change underlying the synchronic pattern was a process of this type (i.e. long-distance assimilation in voicing between obstruents within the foot). This is an important consideration because although synchronically it is tone that is distinctive and voicing predictable, historically the reverse was true. What gave rise to the tone contrast in the first place was, the voicing vs. voicelessness of neighboring consonants (Bradshaw 1979, Ross 1993, 1995). In the diachronic reconstruction of Ross (1993), syllables which contained a voiced obstruent acquired low tone, whereas all others acquired high tone. The latter thus includes syllables containing a voiceless obstruent, as well as syllables without any obstruent. Ross (1988) had earlier suggested that this diachronic process of tonogenesis was preceded by obstruent voicing harmony; this would have constituted a separate sound change, independent from any considerations of tone. If that reconstructed scenario were correct, then it would indeed have been the case that Yabem undergone foot-bounded consonant harmony as a historical sound change (and that the synchronic grammar of Yabem in the stage following that change, but preceding tonogenesis, would have included such a process). Yabem would then count as a refutation of the claim made earlier, that consonant harmony can never be sensitive to prosodic structure.

However, Ross (1993) demonstrates that his earlier reconstruction was problematic in several respects. Instead, he concludes that tonogenesis took place first (as outlined above), and that this was subsequently followed by a general harmony process, defined as in (56). Recall that the foot is iambic and word-final; hence the 'strong' and 'weak' syllables in Ross' formulation are word-final and penultimate, respectively.

(56) Tone and voicing harmony in Pre-Proto North Huon Gulf (Ross 1993)

Where the weak and strong syllables of a foot differed in tone and voicing,

a. if the onset of the *strong* syllable was a Post-Proto Huon Gulf obstruent, the weak syllable acquired the tone and voicing of the strong;
b. otherwise, if the onset of the *weak* syllable was a Post-Proto Huon Gulf (voiced) obstruent, the strong syllable acquired the tone and voicing of the weak.

Note that this historical process is quite analogous to the synchronic spreading process suggested by Bradshaw (1998), in that tone and voicing assimilate as a single property. Indeed, Ross himself describes the change in (46) in exactly this way: 'spreading of voicing and tone occurs together' (Ross 1993:145). The voicing specification of obstruents is significant, in that they act as triggers.[57] However, what they trigger is crucially the combined spreading of tone and voicing, not long-distance voicing assimilation as such. In conclusion, Yabem is not an example of prosody-sensitive consonant harmony, neither synchronically nor diachronically.

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[57] Note that it is only obstruent *onsets* that trigger harmony. A (word-final) coda obstruent will not have this effect, and may in fact have its voicing determined by the harmony process in (56). Thus Proto Huon Gulf **lovok* 'fly' developed into /-lóp/ by a series of segmental changes combined with tonogenesis. After a high-toned prefix such as 1Sg Irrealis /á-/, it has retained this shape: /á-lóp/. By contrast, the 1Sg Realis prefix is low-toned, /gà-/, and the combination /gà-/ + /-lóp/ developed into /gà-lòb/ by (56b). In other words, harmony determined not only the tone of the root syllable, but also the voicing of the final stop; as a result, the root 'fly' alternates synchronically between /-lóp/ and /-lòb/ (with the distribution now being controlled by morphosyntactic factors, such as the realis vs. irrealis distinction).

4. A CONSTRAINT-BASED ANALYSIS OF CONSONANT HARMONY

This chapter develops a generalized phonological analysis of consonant harmony, based on the empirical generalizations that emerge from the typological survey of the preceding two chapters. The analysis is couched in the constraint-based framework of Optimality Theory (OT; Prince & Smolensky 2004 [1993], McCarthy 2002), and makes extensive use of the notion of similarity-based *correspondence* relations between co-occurring segments in the phonological output representation. In this respect, the analytical framework employed here draws heavily upon proposals formulated in earlier work by Walker (2000a, 2000c, 2001), and developed further in Rose & Walker (2004). A few of the cases mentioned in the present study, both in the typological overview in chapter 2 above and in the formal analyses below in this and the following chapter, are analyzed in very similar terms in Rose & Walker (2004). In addition, the analyses presented here make crucial use of the concept of *targeted constraints* as proposed by Wilson (2000, 2001, 2003, 2006; see also Baković & Wilson 2000).

The chapter is structured as follows. Earlier analyses of consonant harmony (and assimilatory co-occurrence restrictions in general) in Optimality Theory are discussed in §4.1. The central components of the proposed model are outlined in §4.2: the basic constraint types on which the analysis relies, and the fundamental constraint-ranking schemata which are required for harmony to arise. Directionality patterns are discussed in §4.3, where it is demonstrated how the attested patterns arise from constraint interaction.

4.1. Earlier Proposals within Optimality Theory

This section examines a few analyses of consonant harmony and related phenomena that have been proposed within the context of Optimality Theory. Section §4.1.1 is a critical examination of analyses which are based on feature spreading, both in the autosegmental sense and in the more concrete articulatory sense of gestural extension. An alternative approach represented by MacEachern's (1999) work on laryngeal co-occurrence restrictions is outlined in §4.1.2, and the problems inherent in extending such an approach to consonant harmony in general are discussed. Finally, inter-segmental correspondence is introduced as a viable alternative for analyzing consonant harmony in §4.1.3. The main focus of this last section is on the general framework developed by Walker (2000a, 2000c, 2001) and applied in Rose & Walker (2004), since this is what forms the basis of the generalized treatment of consonant harmony which is laid out in this chapter and the following one.

4.1.1. Analyses Based on Spreading and Strict Locality

In autosegmental models of phonology, it has typically been taken for granted that all assimilation involves the *spreading* of features or feature classes from one segment to another. As harmony is by definition an instance of assimilation, harmony processes have been regarded as the prime example of feature spreading in this sense. The fact that harmony interactions often give the appearance of involving assimilation at-a-distance, skipping over segments which intervene between the interacting (i.e. harmonizing) segments, raises important questions of *locality*. It is an empirical fact that phonological segments do not interact with each other at arbitrary distances. In non-linear frameworks this problem is solved by appealing to conditions on what counts as a potential F-bearing unit (for some feature [F] that is subject to spreading). Locality is obeyed as long as no relevant F-bearing unit is being skipped in the process (Poser 1982, Steriade 1986, 1987, Shaw 1991, Odden 1994).

Feature geometry, where different features and feature classes are represented along different tiers, allows apparent long-distance assimilations to be interpreted as feature spreading, without resulting in the crossing of association lines. In effect, then, segmental interactions are local in that they involve segments which are adjacent on the relevant autosegmental tier (see Odden 1994 for extensive discussion of locality and adjacency in feature geometry). In some cases, this view necessitates an appeal to *underspecification*; this is especially true for consonant harmony processes, where the trigger and target are often separated by long strings of intervening vowels and non-participating consonants. In her autosegmental treatment of coronal harmony, Shaw (1991) assumes, following Steriade (1987), that any segment that is transparent to harmony in feature [F] must be unspecified for [F] at the point in the derivation when the harmony rule applies. As a consequence, transparent /t/, /n/, etc. in a sibilant harmony systems based on the /s/ vs. /ʃ/ distinction must be underspecified for [±anterior] (and possibly [coronal] as well) and receive their default [+anterior] specification by a redundancy rule or default rule late in the derivation, after the harmony rule has applied.

The use of underspecification in this manner is inherently problematic in output-oriented, parallelist frameworks like Optimality Theory.[1] More recently, numerous works have adopted

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[1] Underspecification in lexical (= Input) representations is by no means contrary to the tenets of Optimality Theory (see Inkelas 1995). However, harmony results from constraints evaluating *surface* (= Output) representations, which must be fully specified (modulo the kind of 'phonetic underspecification' revealed by target-interpolation effects in phonetic implementation; Cohn 1993). What is problematic for OT is the reliance on underspecification at an *in-*

an alternative and much more stringent view of locality in spreading, whereby all spreading is seen to obey *strict locality* (Flemming 1995, Ní Chiosáin & Padgett 1997, 2001, Gafos 1999 [1996], Walker 2000b [1998], Padgett 2002). According to this view, all feature spreading occurs between root-adjacent segments. Any and all segments that fall within a harmony domain are therefore necessarily participants in the harmony: intervening segments are never transparent but permeated by the spreading property (though often covertly, i.e. with little or no audible consequences). A particularly strong version of this view equates featural autosegments with articulatory gestures (as in the Articulatory Phonology model of Browman & Goldstein 1986, 1989, 1992; cf. also Zsiga 1997). Spreading of a feature from one segment to another is then a question of temporally extending a single continuous articulatory gesture, which means that 'skipping' of intervening segments is by definition impossible (see in particular Gafos 1999).

As was discussed in §1.2.3 above, the typology of consonant harmony systems has figured quite prominently in the justification of the strict locality approach. This is because consonant harmony phenomena constitute a much greater challenge to the notion that all phonological interactions respect strict locality than does vowel harmony. In consonant harmony systems the trigger and target segments are often spaced quite far apart, separated by long stretches of (seemingly) transparent vowels and consonants. Recall, however, that the vast majority of consonant harmony processes involve *coronal* harmony. As noted by Flemming (1995), Gafos (1999 [1996]) and Ní Chiosáin & Padgett (1997), the spreading features in coronal harmony interactions are ones which largely correspond to articulatory specifications pertaining to the posture of the tongue tip/blade, and such articulations could easily permeate intervening vowels and non-coronals without interfering with their articulation or acoustic realization in any significant way. This observation, combined with the mistaken but pervasive view that coronal harmony is the *only* attested type of consonant harmony, has lead many researchers to conclude that the strict locality approach to spreading is vindicated.

Optimality Theory analyses of consonant harmony in terms of strict locality make use of the same analytical devices as have usually been applied in spreading-based analyses of vowel harmony, nasal harmony, and so forth. For example, both Gafos (1999) and Ní Chiosáin & Padgett (1997) assume that consonant harmony is driven by featural alignment constraints (ALIGN-L[F], ALIGN-R[F]), which require the featural element in question, or the articulatory gesture instantiating that feature, to be extended as far as possible toward a designated edge of some prosodic or morphosyntactic domain.[2] Thus, for example, Gafos (1999:218) defines the constraint responsible for anticipatory (right-to-left) coronal harmony

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termediate level of phonological representation, which is precisely what traditional autosegmental spreading rules were typically producing as their output.

[2] In the shorter published (2001) version of Ní Chiosáin & Padgett (1997), which is largely focused on the spreading of *vowel* features across neighboring consonants, the constraints driving feature spreading are those of the SPREAD[F] family (see Walker 2000b). The formal properties of SPREAD[F] constraints are subtly different from those of ALIGN[F].

in Tahltan as ALIGN(TTCA, Word, L). This constraint requires that any specification in terms of the gestural parameter TTCA (Tongue-Tip Constriction Area) should extend leftwards to reach the left edge of the word.

Any segment that shows resistance to taking on the spreading feature [F]—either due to some context-free Markedness constraint on possible segment types (feature co-occurrence constraints) or high-ranked Faithfulness to underlying [±F] specifications in that particular segment type—will block the propagation of harmony. This is how both Gafos (1999) and Ní Chiosáin & Padgett (1997) capture the fact that Sanskrit *n*-retroflexion is blocked by any coronal obstruent (see §3.2.3 for relevant examples and discussion). Gafos interprets the retroflexion process as assimilation involving the gestural parameter (tract variable) Tongue-Tip Constriction Orientation (TTCO), more specifically the value [retroflex] of that parameter. Nasals are differentiated from obstruents in terms of their susceptibility to retroflexion by the ranking FAITH(TTCO, Obstruent) >> FAITH(TTCO, Nasal). The ALIGN(TTCO=[retroflex], R) constraint responsible for retroflexion spreading outranks only FAITH(TTCO, Nasal) but not FAITH(TTCO, Obstruent). As a result, coronal obstruents resist retroflexion and thus block the rightward propagation of the [retroflex] property across the word.[3]

As argued elsewhere in this work, there are several flaws with the strict locality approach to consonant harmony, only a few will be mentioned here. Firstly, note that this approach is based on the assumption that consonant harmony is feature (and/or gesture) spreading. It is possible to retain the fundamental tenet of the strict locality approach—that feature spreading always targets root-adjacent segments and that skipping is universally impossible—while interpreting consonant harmony as involving a mechanism other than feature/gesture spreading. Secondly, the strict locality approach to consonant harmony is based on the empirically false assumption that coronal harmony is the *only* attested type of long-distance assimilatory interactions among consonants; the truth is that it is simply the *most common* type. Some of the other attested types cannot by definition involve local spreading of articulatory gestures (e.g. nasal consonant harmony, obstruent voicing harmony, stricture harmony, etc.). The true empirical generalization appears to be that *sibilant* harmony, rather than coronal harmony in general, is the predominant type of consonant harmony. Sibilants are also frequently involved in long-distance interactions in phonological speech errors (where gestural spreading is clearly not involved; see §6.1). This fact, combined with other striking parallels between consonant harmony patterns and common speech error patterns (discussed in §6 below), strongly suggests that other mechanisms than feature spreading or gestural extension may well underlie phonological consonant harmony interactions.

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[3] Instead of Faithfulness, Ní Chiosáin & Padgett (1997) appeal to constraints that demand *contrast* in the feature in question ([retroflex] vs. non-[retroflex]). The relevant constraints are $\text{CONTRAST}_{\text{NAS}}$(RET) for nasals and the cover constraint $\text{CONTRAST}_{\text{CONS}}$(RET) for oral consonants. The ranking $\text{CONTRAST}_{\text{CONS}}$(RET) >> ALIGN-R(RET) >> $\text{CONTRAST}_{\text{NAS}}$(RET) is what gives rise to the Sanskrit pattern in their analysis.

Another important objection is that the strict locality approach wrongly predicts that segmental opacity is as much to be expected in consonant harmony systems as it is in vowel harmony or nasal harmony systems, since these are all assumed to be equivalent phenomena. For example, in Yoruba tongue-root harmony, high vowels are required to be [+ATR] and block the left-to-right propagation of [–ATR] harmony (see, e.g., Archangeli & Pulleyblank 1989). There is no a priori reason why a language with apical/laminal sibilant harmony could not in the same way require its stops /t, d/ to be specified as laminal in output representations, and thus block the propagation of sibilant harmony. As we saw in §3.2, however, opacity of this kind is essentially *never* observed in consonant harmony.[4] Segments are either 'legitimate targets', and as such are affected by harmony, or they are completely inert and freely allow the harmony feature to propagate across (or through) them. This typological fact is highly surprising under the strict locality approach.

The strict locality approach assumes that any intervening segment that appears to be transparent is in fact permeated by the spreading feature (and the articulatory gesture it represents). True transparency, if it exists at all, must on this approach be accounted for as a special phenomenon requiring special analytical devices (see Ní Chiosáin & Padgett 1997, Walker 2000b, 2003). It should however be kept in mind that the evidence that intervening segments in coronal harmony systems are permeated rather than genuinely transparent is conjectural: it is argued that the relevant feature/gesture *might* be maintained through such segments with little acoustic-perceptual effects. This conjecture has thus far not been confirmed with instrumental phonetic studies on an existing coronal harmony system.[5] As we saw in §3.2.2, concrete evidence often points instead towards genuine transparency. Moreover, in many cases the need to assume 'permeability' rather than transparency forces defenders of the strictly-local spreading approach to coronal harmony to call into question the accuracy of available descriptive studies. In his discussion of Chumash sibilant harmony, where the non-sibilants /t, n, l/ are (allegedly) transparent, Gafos (1999:183–184) explicitly assumes that the realization of a non-sibilant coronal like /n/ will vary depending on the harmonic domain in which it happens to be contained. Gafos takes the relevant parameter to be an apical vs. laminal distinction, and gives the following schematic example (transcription of apical vs. laminal [n] has been adjusted to IPA standards, but traditional 'S' vs. 'Š' has been kept as the representation of the respective sibilant series):

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[4] The recently discovered case of opacity in Rwanda (Kinyarwanda) sibilant retroflexion harmony (Walker & Mpiranya 2005, Walker et al. 2008, Hansson 2007b) is a possible exception, though much is yet unclear about the phonological nature of that phenomenon. For arguments that another well known apparent counterexample to the above claim, Sanskrit *n*-retroflexion, is not a case of consonant harmony (in the relevant sense) at all, see §3.2.3.

[5] Recent phonetic studies of (allegedly) transparent vowels in some vowel harmony systems have suggested that these might not be transparent but rather carry the spreading feature or gesture to some extent (Gordon 1999, Gick et al. 2006, Benus & Gafos 2007).

(1) Non-sibilants in Chumash coronal harmony (Gafos 1999:183)
Apical domain: /…N…S/ → […n̺…S]
Laminal domain: /…N…Š/ → […n̻…Š]

In other words, the theory of strict articulatory locality forces us to assume that /n/ must have apical vs. laminal allophones, [n̺] vs. [n̻], the distribution of which is governed by coronal harmony. Since coronal harmony involves leftward spreading of apicality/laminality towards the left edge of the word, an /n/ (Gafos' /N/) in any position will be apical [n̺] if an apical (S-series) sibilant follows somewhere later in the word, and laminal [n̻] if there is instead an upcoming laminal (Š-series) sibilant. (Nothing is said about which is the 'elsewhere' realization of /n/ when no sibilant follows: apical [n̺] or laminal [n̻].) Gafos proposes that 'the reason why the nasal N and the other coronal stops are transparent is that the two stop articulations […] are not contrastive in Chumash and are thus not perceived as distinct' (1999:182). We have no detailed phonetic data from any of the (now extinct) Chumashan languages, but Gafos adds that neither Beeler (1970) nor Harrington (1974 [1928]) report any apical-laminal contrasts for the non-sibilant coronals. This is certainly true, but these studies also fail to mention any of the *allophonic* apical/laminal variation for /t, n, l/ which the local spreading approach crucially assumes to be present in Chumash.

There are cases where the relevant descriptive sources do generally go into a considerable amount of detail in describing sub-phonemic variation in the realization of various consonants, but the specific allophonic differences predicted by the local spreading approach are conspicuously absent from all such descriptions. A case in point is the coronal harmony of numerous Western Nilotic languages (see §2.3 and §2.4.1.2), where contrastively dental vs. alveolar consonants harmonize with each other. In some languages both stops and nasals maintain the dental-alveolar contrast, and harmonize with each other (e.g. Päri, Anywa, Shilluk).[6] Sequences like [d…n] or [d̪…n̪] are thus allowed, whereas *[d̪…n] is not. However, in some of these languages, the dental-alveolar contrast is absent in nasals (e.g. Luo, Mayak). In these languages, /n/ is described as being consistently alveolar, and is neutral to coronal harmony, co-occurring with dental and alveolar stops alike (the same is also true of /l, r/ in all the languages). The local spreading approach must assume that in such cases, the nasal /n/ *is* in fact realized alternately as alveolar [n] or dental [n̪] depending on the harmonic domain in which it occurs. We are thus forced to believe that even in languages with the single nasal /n/, the harmony facts are exactly the same at the *phonetic* level: [d…n] and [d̪…n̪] occur but not *[d̪…n]. If this had indeed been the case, there is little doubt that it would have been noted in at least some of the relevant descriptive literature. In his description of Mayak, one of the languages with a single /n/ instead of a /n/ : /n̪/ contrast, Andersen (1999) does note that /n/ is realized as dental [n̪] when immediately followed by a dental stop. We thus find dental [n̪] in

[6] As noted in §2.4.1.2, the distribution of dental [n̪] in Anywa is largely predictable (Reh 1996, Rose & Walker 2004, Mackenzie 2005), and Anywa may thus be a rare example of non-structure-preserving consonant harmony (cf. §5.1.2 on Nkore-Kiga sibilant harmony).

the clusters /nd̪/, /nt̪/, but alveolar [n] elsewhere. Had it been the case that dental [n̪] also occurred in contexts like /d̪…n/ or /t̪…n/ as a result of coronal harmony, this would surely have been noted in Andersen's description.

Interestingly, Ní Chiosáin & Padgett (1997) invite the possibility that intervening segments in consonant harmony may be genuinely transparent—that is, not permeated by the propagating feature. They concede that true transparency certainly does exist in some cases of vowel harmony, and conjecture that the same might perhaps be true of some consonant harmony cases as well. The hypothetical example they mention is a coronal harmony system 'in which a learner fails to maintain the tongue tip/blade gesture throughout a domain of spreading, because its effect isn't audible in non-sibilant segments'. By an imperfect-learning scenario of this kind, *apparent* (perceptual) transparency becomes reanalyzed as *genuine* (articulatory) transparency. This is certainly an interesting idea, especially from the point of view of the diachronic development of individual consonant harmony systems, although it creates a loophole which renders the local spreading approach to consonant harmony empirically unfalsifiable. It also reminds us of the fact that as long as the presence of the spreading feature/gesture on intervening segments (especially intervening non-coronals) is largely inaudible, the observed interaction pattern that a learner must discover, and assign some systematic interpretation, is effectively a *non-local* relation even under the strict locality assumption.[7] In any case, the fact remains that the local spreading approach treats such genuine transparency as an aberration rather than the norm, and expects opacity where none is to be found.

As mentioned above, analyses of consonant harmony under strict locality have generally used ALIGN[F] (or SPREAD[F]) constraints to drive the spreading of the harmony feature or gesture in some designated direction. For example, the constraint ALIGN(TTCA, Word, L) in Gafos' (1999 [1996]) analysis of Tahltan coronal harmony is intended to capture the fact that it is the rightmost coronal (of the relevant kind) that determines the TTCA value for all preceding segments. Interestingly, however, neither Gafos nor Ní Chiosáin & Padgett (1997) notice the inability of ALIGN-L by itself to produce this directionality effect. Consider the hypothetical inputs /sVʃV/ and /ʃVsV/, which ought to yield the outputs [ʃVʃV] and [sVsV], respectively, given the leftward directionality of Tahltan coronal harmony, which is explicitly encoded in the ALIGN-L constraint. As the tableaux in (2) show, the mere high ranking of ALIGN-L(TTCA) is not sufficient to derive the correct directionality (brackets indicate the extent of the relevant TTCA gesture).

[7] Thanks to Robert Kirchner for calling my attention to this fact, and to its implications for learning algorithms (see Albright & Hayes 2003, Hayes & Wilson 2008). For (brief) discussion of learnability-related issues concerning the long-distance dependencies involved in consonant harmony, see chapter 7.

(2) Inadequacy of ALIGN[F] for capturing fixed directionality:

/sVʃV/	ALIGN-L(TTCA)	FAITH(TTCA)
a. [s][Vʃ]V	*!	
b. ☞ [ʃVʃ]V		*
c. ☞ [sVs]V		*

/ʃVsV/	ALIGN-L(TTCA)	FAITH(TTCA)
d. [ʃ][Vs]V	*!	
e. ☞ [sVs]V		*
f. ☞ [ʃVʃ]V		*

The desired winners are (2b) and (2e), respectively. However, candidates (2c) and (2f) do just as well, even though their harmonic domain contains the 'wrong' TTCA value. The reason is that the ALIGN constraint does not (and cannot) specify *which* TTCA value is to be aligned with the left edge of the word in each case. As long as any and all output TTCA specifications are aligned properly, the constraint is satisfied. It is for this reason that ALIGN-based analyses of vowel harmony systems end up invoking other constraints—such as output-output faithfulness to the base of affixation (Baković 2000) or positional faithfulness in root vowels (Ringen & Vago 1998, Ringen & Heinämäki 1999)—so as to correctly identify the spreading trigger.

As noted in §3.1, consonant harmony systems often exhibit a fixed anticipatory (right-to-left) directionality which appears to be blind to the morphological affiliations of potential trigger and target segments. In such cases, faithfulness cannot be appealed to in order to determine which of the segments will lend its feature value to the entire harmonic span. This difficulty in deriving fixed directionality is a general problem, arising from the output-oriented character of Optimality Theory (Hansson in prep.), and one aspect of it will rear its head again in §4.2.3. For our present purposes, it suffices to point out that the spreading-based analyses of (coronal) consonant harmony advocated by Gafos (1999) and Ní Chiosáin & Padgett (1997) are fundamentally inadequate in ways which have not been acknowledged or addressed in works advocating such analyses.

4.1.2. The Complete-Identity Effect and BEIDENTICAL

In her typological study of laryngeal co-occurrence restrictions, MacEachern (1999 [1997]) formulates constraint-based analyses of such restrictions in a wide range of languages. For the most part, the restrictions dealt with are dissimilatory in nature; for example, Cuzco Quechua does not permit two ejectives to co-occur within the same morpheme. MacEachern accounts for such patterns by adopting the generalized Obligatory Contour Principle schema argued for by Suzuki (1998).[8] In Suzuki's formulation, OCP constraints are insensitive to factors such as relative trigger-target proximity (of which direct adjacency is the limiting case). For Cuzco Quechua, the relevant OCP constraint is *[constricted glottis]…[constricted glottis], here abbreviated *2CG for simplicity. The example in (3) illustrates how the dissimilatory effect arises from the ranking schema *2[F] >> MAX[F].

(3) Laryngeal dissimilatory pattern in Cuzco Quechua roots (MacEachern 1999)

/t'ak'a/	*2CG	MAX[c.g.]
a. t'ak'a	*!	
b. ☞ t'aka		*

The example in (3) involves heterorganic ejectives, but the dissimilatory restriction in Cuzco Quechua does not distinguish between heterorganic and homorganic sequences; thus, /t'at'a/ is prohibited (and dissimilated to [t'ata] by the above constraint ranking) just as /t'ak'a/ → [t'aka].

Unlike Cuzco Quechua, several of the languages examined by MacEachern (1999) display what she refers to as the *complete identity effect*. In such languages, violation of the relevant OCP constraint is allowed just in case the two segments in question are identical in all respects (Frisch et al. 2004, Frisch 2004, Gallagher 2008, Gallagher & Coon 2009; see §2.4.8 above). In other words, [t'at'a] is allowed even though *[t'ak'a] is not. One such system is the dialect of Aymara which MacEachern labels 'Peruvian' Aymara. To account for this total-identity exemption, MacEachern proposes a new type of constraint, BEIDENTICAL, defined as follows:

(4) BEIDENTICAL (from MacEachern 1999 [1997])

Segments should be identical. One violation is assessed for every pair of non-identical segments.

Given an input /t'at'a/, high-ranked BEIDENTICAL prefers the (faithful) candidate [t'at'a] over the dissimilated *[t'ata]. However, this is not enough, since a third competitor, *[tata], fares even better by satisfying both BEIDENTICAL and *2CG:[9]

[8] Other proposals for treating OCP effects in Optimality Theory include the self-conjunction of context-free Markedness constraints (Itô & Mester 1996, Alderete 1997).

[9] For simplicity, only consonant violations of BEIDENTICAL are counted here (and throughout). Given the definition in (4), violations should in principle also be counted for C-V and V-V pairs. For example, a hypothetical 5-segment string like [kunap] should get 10 violations (4+3+2+1).

(5) Complete identity effect in Peruvian Aymara (wrong result!)

/t’at’a/	BEIDENTICAL	*2CG	MAX[c.g.]
a. ☹ t’at’a		*!	
b. t’ata	*!		*
c. ☞ tata			**

In order to get around this problem, MacEachern invokes yet another constraint which has the exact opposite effect of BEIDENTICAL, namely to *prohibit* the co-occurrence of identical segments. This constraint, referred to here as *IDENTITY, is in practice nothing more than an OCP constraint on (identical) root nodes. The distribution of *IDENTITY violations in the tableau is exactly complementary to that of BEIDENTICAL violations (the former penalizes precisely those candidates that the latter doesn’t penalize). Regardless of its ranking, merely adding *IDENTITY to the tableau will therefore not help promote candidate (5a) over (5c), as both would violate this constraint equally. Instead, MacEachern combines the two OCP constraints, *IDENTITY and *2CG, into one *conjunctive* constraint (in the sense of Hewitt & Crowhurst 1996), as paraphrased in (6).[10]

(6) *IDENTITY ∧ *2CG

The co-occurrence of one or more of the following is prohibited: a pair of identical segments, or a pair of [constricted glottis] segments.[11]

Replacing *2CG with the conjunctive constraint *IDENTITY ∧ *2CG gives the right result, allowing a double-ejective candidate like [t’at’a] to emerge as the optimal one, as shown in (7). This is because the (logical) conjunction has the effect of collapsing violations of *2CG and *IDENTITY into a single violation. Even though [t’at’a] violates both *2CG and *IDENTITY, while [tata] violates only the latter, the two candidates tie on the conjunctive constraint

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[10] The actual conjunctive constraint that MacEachern proposes is even more complex, in that it involves a third conjunct, the OCP constraint *2(LAR ∨ [–sonorant]). This constraint serves to prohibit the co-occurrence of ejectives and aspirates (obstruents with a Laryngeal node). For simplicity, this aspect of the Peruvian Aymara co-occurrence restrictions is ignored here.

[11] Note that constraint conjunction as defined by Hewitt & Crowhurst (1996) treats constraints in a Boolean fashion: *IDENTITY ∧ *2CG requires a pair of co-occurring segments not to be identical *and also* not to be a T’…T’ pair. It is violated whenever a segment pair violates one or the other of the conjuncts (or both). By contrast, what is usually referred to as ‘constraint conjunction’ in most other works in Optimality Theory (going back to Smolensky 1995; see McCarthy 2002a) is equivalent to logical *dis*junction in the Boolean sense: composite constraints of that kind are satisfied when one or both of their component constraints are obeyed (and hence violated only when neither constraint is satisfied).

in (6). In effect, (6) requires that candidates satisfy both *IDENTITY and *2CG simultaneously; neither [t'at'a] nor [tata] satisfy this criterion, and each thus receives exactly one violation mark. The choice is thereby passed along to lower-ranked MAX[c.g.], which prefers the faithful (7a) over the maximally unfaithful (7c).

(7) Complete identity effect in Peruvian Aymara (revised)

/t'at'a/	BEIDENTICAL	*IDENTITY ∧ *2CG	MAX[c.g.]
a. ☞ t'at'a		*	
b. t'ata	*!		*
c. tata		*	*!*

Though MacEachern's (1999) approach does manage to capture the relevant patterns of co-occurrence restrictions, there is reason to be skeptical of its general validity. Firstly, the analysis makes crucial use of logical constraint conjunction and disjunction. These are extremely powerful extensions to standard Optimality Theory, and their effects on the overall generative capacity of the theory have by no means been explored thoroughly enough. Secondly, the interdependence of BEIDENTICAL and *IDENTITY, two constraints that are polar opposites of each other, is rather suspect. Wherever BEIDENTICAL plays any role in deriving co-occurrence effects in the languages that MacEachern considers, it does so by immediately outranking some large conjunctive constraint of the type *IDENTITY ∧ *2[F] (where [F] is some feature targeted by the OCP in the language in question). It is this interplay, rather than the constraint BEIDENTICAL as such, that derives the complete identity effect. Nowhere do we see the constraint BEIDENTICAL 'acting alone', as it were.

Finally, there are problems with the definition of BEIDENTICAL itself and its effects. For example, it is not entirely clear which segment pairs are supposed to fall within its scope. If this constraint evaluates any and all pairs of segments in the output string, then one might expect total-assimilation effects between consonants and vowels, given the right constraint ranking, a somewhat counterintuitive result. Furthermore, evaluation along these lines effectively puts BEIDENTICAL in league with so-called *quadratic* constraints, which display various computationally and typologically problematic properties (Eisner 1997, McCarthy 2003b, Riggle 2004, Heinz 2005, Hansson 2006a, 2007b). A more serious drawback is the fact that BEIDENTICAL refers only to total identity, rather than to identity in some particular feature or feature class, or to some measure of overall similarity. From the point of view of this constraint, segment pairs that differ only in one or two features, such as [k']/[k] or [s]/[ʃ], are entirely equivalent to much less similar pairs like [k']/[ð] or [m]/[ʃ]. This does not cause problems in the particular cases that MacEachern (1999) analyzes, but it greatly reduces the potential applicability of the constraint to the wider range of phenomena considered in the present study (see §2.4.8 above for related discussion).

Interestingly, MacEachern justifies BEIDENTICAL by motivating it in the domain of articulatory planning, and suggests that it may have other linguistic effects as well:

> The preference for identical segments is likely to have an articulatory basis: programming two identical segments is probably easier than programming two different segments. Linguistic phenomena such as morphological reduplication, segment harmony processes in child speech, and reduplication processes among speakers with language deficits may offer other illustrations of this constraint in action. (MacEachern 1999:93)

Although consonant harmony in adult language is not among the phenomena listed here, her mention of harmony in child language is suggestive. If BEIDENTICAL is thought to be what is responsible for consonant harmony processes in child speech, then it might well be applicable to adult consonant harmony as well. However, the rigidity of BEIDENTICAL is problematic here as well. Even in child language, consonant harmony frequently results in partial rather than total identity, enforcing assimilation in some isolated property (place, nasality, etc.) while leaving others unaffected, yielding forms like [gɪŋk] 'drink', [dut] 'boot', [minz] 'beans', etc. The same is true *a fortiori* of consonant harmony in adult language, which normally involves agreement in a specific feature, not identity in all features.

To be fair, MacEachern's analysis is focused on co-occurrence restrictions on laryngeal features specifically, and certainly does not purport to offer a formal account of consonant harmony in general.[12] It turns out, however, that even within the class of laryngeal co-occurrence restrictions there are systems which involve agreement in particular features without necessarily leading to total identity. Though the set of languages examined by MacEachern (1999) does not include any such cases, several were reported in §2.4.7 above. For example, the obstruent voicing harmony seen in Kera (Chadic) and Ngizim (Chadic) holds between heterorganic and homorganic obstruents alike, and in Ngizim, even between stops and fricatives (heterorganic as well as homorganic). Likewise, the laryngeal harmony

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[12] From MacEachern's introductory discussion of 'co-occurrence restrictions' as a general phenomenon (1999:3–4), it nevertheless appears that she considers consonant harmony to be homologous to the (mostly dissimilatory) phenomena to which her study is devoted. For example, her description of the essence of Chumash sibilant harmony is that '[w]ords do not contain sibilants that differ in place of articulation'. Perhaps not incidentally, the examples chosen as illustrations involve otherwise-identical sibilants (/osos/ 'heel', /pʃoʃ/ 'garter snake', but */osoʃ/). In the subsequent discussion MacEachern further paraphrases the Chumash co-occurrence restriction as prohibiting 'non-identical sibilants' from co-occurring. This is a gross oversimplification, since non-identical sibilants are perfectly free to co-occur in Chumash words, as long as they agree in [±anterior] (e.g. [s…ts], [tʃ…ʃ]). If Chumash sibilant harmony were as simple as MacEachern implies, then it could indeed be captured with the help of BEIDENTICAL. Unfortunately, the facts of this and most other consonant harmony systems go far beyond this simple all-or-nothing characterization.

found in some southern Bantu languages (Zulu, Ndebele) holds regardless of differences in place of articulation. The same is true of the root-internal implosive harmony observed in Ijoid languages (Kalabari Ijo, Bumo Izon), which allow sequences like [ɓ…ɗ] but not disharmonic *[b…ɗ] or *[ɓ…d].

In short, there is reason to believe that the 'complete-identity effect' observed by MacEachern is merely a specific instantiation of a more general phenomenon. In a sense, the total identity pattern constitutes the limiting case, where the two interacting segments *already* agree in all other properties. The survey in chapter 2 includes numerous instances of consonant harmony systems, based in a wide range of phonological features, where the harmony is parasitic on identity in other features.

Even though the analysis by MacEachern (1999) is too constrained to account for the full range of attested laryngeal co-occurrence restrictions, let alone consonant harmony in general, it nevertheless has certain attractive aspects. For example, this analysis does predict that any segmental material intervening between the two interacting consonants should be entirely irrelevant, something which is indeed characteristic of consonant harmony (see §3.2 above). Furthermore, MacEachern's idea that the 'identity effect' (and BEIDENTICAL as such) has its roots in the domain of articulatory planning is very much in line with the formal analysis of consonant harmony phenomena presented below. That analysis is founded on proposals which were originally developed in earlier work by Walker (2000a, 2000c, 2001) and Rose & Walker (2000), to which we now turn.

4.1.3. Correspondence-Based Analyses of Consonant Harmony

As argued in the previous section, it appears necessary to relax somewhat the requirement that co-occurring segments in the output be fully identical, such that the segments in question are instead merely required to be identical with respect to some designated feature (or perhaps a feature class in the sense of Padgett 2002). Constraints demanding such segment-to-segment featural identity would be suspiciously similar to a pre-existing family of constraints in Optimality Theory, namely *correspondence constraints*, in particular IDENT[F]. The similarity is quite striking: segments that stand in a correspondence relation to each other (e.g. in the input vis-à-vis output representations, or in a reduplicant affix vis-à-vis the base of reduplication) are required to be featurally identical, and each individual IDENT[F] constraint penalizes disagreement with respect to some feature [F].

Might it be possible to reduce some or all instances of consonant harmony to the requirement of featural identity (total or partial) under some notion of *correspondence*? In order to answer this question, we must first consider in what sense C_1 and C_2 in a sequence [...C_1...C_2...] could be said to stand in a correspondence relation to one another. First of all, these correspondent segments (if that is what they are) are part of the same output string. Input-Output correspondence is thus ruled out as a possibility, and so is Output-Output correspondence in the usual sense of relations between forms in the same morphological paradigm (Benua 1995, 2000, Kenstowicz 1996, 1997, Steriade 2000). Within the standard version of

Optimality Theory, the only type of correspondence relation that can hold between different portions of a single output string is Base-Reduplicant (BR) correspondence (McCarthy & Prince 1993, 1994, 1995, 1999).

There have indeed been proposals appealing to BR correspondence to account for certain effects which appear to involve long-distance agreement or identity between consonants. Gafos (1998) proposes that phenomena previously analyzed as 'long-distance consonantal spreading' (LDC-spreading) actually involve identity due to BR correspondence. The best-known examples involve non-concatenative (root-and-pattern) morphology of the kind found in Semitic languages. In Modern Hebrew denominal verb formation, a biconsonantal noun like /kod/ 'code' is mapped onto a CVCVC template, along with the vocalic melody /ie/, to yield the verb [kided] 'to code'.[13] In earlier approaches, the realization of both C_2 and C_3 as [d] was explained in terms of spreading of the entire root node of [d] to both C positions, across the intervening vowel. This was possible under the assumption that in languages with non-concatenative morphology, consonantal and vocalic melodies reside on different planes (McCarthy 1981, 1985), such that the intervening vowel will not block the spreading. In his reinterpretation of such phenomena, Gafos (1998) rejects LDC-spreading altogether, as well as the notion of V/C planar segregation. Instead, he suggests that the vocalic melody /ie/ is a *reduplicative* morpheme (/ie^{RED}/). It is only when the consonantal material of the input is less than what is required by the CVCVC template that the reduplicative character of the affix can emerge. The reduplication is thus visible in the verb [kided] from /kod/ (where C_3 'copies' C_2), but not in [jiven] 'to hellenize' from /javan/ 'Greece'. The constraints ALIGN^{AFF}-R and ANCHOR-R together ensure that the reduplicant is spelled out on C_3 (rather than on C_1 or C_2) and that the reduplicant C_3 corresponds to C_2 [d] rather than to C_1 [k].

For most cases of consonant harmony, it is not feasible to appeal to the mechanism of BR correspondence as an explanation. Nevertheless, there are a few individual cases where it might be relevant. One potential example is the /-ar-/ infix in Sundanese, which was cited in §2.4.5 as a possible case of liquid harmony due to the fact that the infixal /r/ assimilates to a base-initial /l/ (cf. [k-<u>ar</u>-usut] from /kusut/ 'messy', but [l-<u>al</u>-ɨtik] from /lɨtik/ 'small'). In his analysis of the assimilatory and dissimilatory behavior of the Sundanese /-ar-/ infix, Suzuki (1999) suggests that the assimilation just noted is due to the infix being a reduplicative morpheme, /-aL^{RED}-/, where /L/ represents an underspecified liquid. Other things being equal, the /L/ of the infix surfaces as [r], due to the context-free markedness constraint *l. When the base-initial consonant is itself a liquid, then the realization of /L/ will be determined by undominated IDENT(LIQ)-BR, which requires corresponding segments to agree with respect to the feature [LIQUID] (largely equivalent to [±lateral]).[14] For further discussion of Sundanese liquid assimilation and dissimilation, see §4.3.3.

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[13] Strictly speaking, the template is simply a disyllabic foot [σ σ]; undominated FINAL-C ensures that the stem will end in a consonant (thus CVCVC rather than CVCV).

[14] In addition to BR correspondence, Suzuki (1999) invokes a special kind of string-internal correspondence (between adjacent-syllable onsets), not unlike Walker's proposal discussed

Note that the effect is agreement in [LIQUID] (or [±lateral], alternatively) between two liquids co-occurring in the same output string. The infix consonant never assimilates, completely or in part, to a *non*-liquid in base-initial position. Nevertheless, it is possible to account for the liquid agreement as a matter of identity under BR correspondence, for two reasons. The first is the fact that the assimilation is a property of one particular morpheme (/-ar-/), and that this morpheme is an affix. This makes it feasible to stipulate that this particular affix is reduplicative. Secondly, the assimilation trigger is always in the same position; moreover, this position happens to be at the (left) *edge* of the base to which /-ar-/ is being affixed. Under most analyses of reduplication in Optimality Theory, constraints such as ANCHOR-L would ensure that it is the base-initial consonant, rather than a base-medial or base-final consonant, to which the infixal liquid corresponds.

Although Base-Reduplicant correspondence is quite possibly involved in cases such as Sundanese liquid harmony, the same is not true in the vast majority of consonant harmony systems surveyed here. For example, in many cases, root consonants harmonize with affix consonants. Furthermore, BR correspondence is of no help in cases of morpheme-*internal* harmony—that is, static (assimilatory) co-occurrence restrictions (though see Zuraw 2002). If correspondence is to provide the basis for a generalized analysis of consonant harmony phenomena, we must look elsewhere. Crucially, the type of correspondence relation involved cannot be assumed to be Base-Reduplicant or Input-Output, or even Output-Output correspondence, but must instead belong to a separate domain—one involving some kind of *string-internal* correspondence. The question is then whether segments can be assumed to stand in a correspondence relation to one another merely by virtue of co-occurring in the same (output) string? Interestingly, several recent works argue this to be the case for *adjacent* segments. The clearest, most elaborate example is Krämer (2001, 2003), who proposes a separate family of SYNTAGMATIC IDENTITY (S-IDENT[F]) constraints, parallel to the IDENT[F] constraints that are involved in other correspondence dimensions (IO, BR, etc.). Krämer's definition of S-IDENT[F] constraints is as shown in (8). Note that this definition allows for agreement in [F] to hold between higher prosodic units (syllables, feet, etc.), and it also allows the agreement to be bounded by prosodic domains (the syllable, the foot, the prosodic word, etc.).

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below. He suggests that a special constraint IDENT$\sigma_1\sigma_2$(rhotic)$_{ONS}$ be responsible for the failure of /r…r/ → [l…r] dissimilation in forms like [c-a.r-u.ri.ga] 'suspicious (pl.)' (not dissimilated to *[c-a.l-u.ri.ga]). The OCP constraint against [r…r] sequences is overridden by this constraint, which requires onset rhotics in adjacent syllables to be identical. See §4.3.3 for further discussion and analysis of the Sundanese case.

(8) S-IDENT[F] (Krämer 2001)

Let *x* be an entity of type *T* in domain *D*, and *y* be any adjacent entity of type *T* in domain *D*, if *x* is [αF] then *y* is [αF].

T ∈ {segment, mora, syllable, foot}

D ∈ {PPh, PWd, foot, syllable}

(Within a Prosodic Phrase, Prosodic Word, foot or syllable, a segment, mora, syllable or foot must carry the same value for feature [F] as the adjacent segment, mora, syllable or foot in the output representation.)

Krämer (2001, 2003) appeals to this kind of correspondence-by-adjacency in order to analyze vowel harmony and dissimilation, among other syntagmatic effects. In his analysis of vowel harmony, Baković (2000) advocates a largely equivalent proposal, invoking constraints of the type AGREE[F], as defined in (9):[15]

(9) AGREE[F] (Baković 2000)

Adjacent segments must have the same value of the feature [F].

The notion of assimilation as agreement under adjacency can be paraphrased as follows. Adjacent segments—and possibly higher-level entities as well—automatically stand in a correspondence relation to one another. This correspondence relation is evaluated (as to its 'faithfulness') by a set of special S-IDENT[F] constraints, just as IDENT[F]-IO compares input-output correspondent pairs, IDENT[F]-BR base-reduplicant correspondent pairs, and so forth. Note that other types of correspondence constraints are inapplicable in the case of syntagmatic correspondence, since the correspondence mapping relates individual *segments* rather than whole *strings* of segments. CONTIGUITY and LINEARITY, which enforce the preservation of precedence relations within corresponding strings, are thus meaningless in this case, and MAX and DEP are likewise vacuous. In short, the constraints applicable to syntagmatic correspondence are primarily IDENT[F].

Correspondence under adjacency is clearly not adequate for dealing with consonant harmony, since the trigger and target segments are usually at a considerable distance from one another, and any intervening segmental material is consistently irrelevant, as discussed in §3.2.2 above. We would therefore need to appeal to a *non-local* version of syntagmatic correspondence, a relation holding between segments that are not necessarily string-adjacent. How would such a correspondence relation be construed? Going back to MacEachern's (1999) analysis with BEIDENTICAL, we can say that it reflects the simple idea that any and all seg-

[15] The AGREE family of constraint is argued for by Lombardi (1999). Related proposals include ASSIM in Gnanadesikan (1997) and the IDENTICAL CLUSTER CONSTRAINT family of Pulleyblank (1997). In effect, AGREE[F] is subsumed under the more general *XY constraint schema proposed by Pulleyblank (2002) for co-occurrence restrictions of all kinds.

ments in the output string 'correspond' to each other (in the sense that there is a pressure towards them being identical). However, the fact that consonant harmony tends to involve segment pairs that are (already) similar along several parameters suggests that a more subtle interaction may be involved. Is it perhaps possible that similarity per se is the crucial factor in establishing a correspondence relation between consonants?

In a series of papers, Rachel Walker and Sharon Rose have developed a detailed correspondence-based analysis of certain types of long-distance assimilatory interactions among consonants (Walker 2000a, 2000c, 2001, Rose & Walker 2000, 2004; see also Rose 2004). Following Rose & Walker (2004), this model will here be referred to as the Agreement by Correspondence (ABC) model. In the ABC model, the more similar two co-occurring segments in the output string are, the greater the pressure for them to stand in correspondence with one another, and thus to be potentially required to agree in one or more features (by means of IDENT[F] constraints). In Walker's early work using this approach, the particular cases analyzed in this way are morpheme-internal voicing and nasality agreement among homorganic consonants in Ngbaka (Thomas 1963, Mester 1988b), obstruent voicing agreement in Kera (Ebert 1979, Odden 1994; see also Hansson 2004a, Pearce 2005, 2006, 2009), and the nasal consonant harmony observed in various Bantu languages, such as Yaka, Kongo and Lamba (Odden 1994, Hyman 1995, Piggott 1996).[16] Hansson (2001b) and Rose & Walker (2000, 2004) extend the ABC analysis to the typology of consonant harmony phenomena as a whole. As the analysis of consonant harmony that will be presented in this and the following chapter borrows quite heavily from this work (in particular Walker 2000a, 2000c, 2001), the ABC approach will therefore be described in some detail.[17]

The idea that correspondence is triggered by similarity is based on the assumption that the long-distance interactions in question are motivated in the domain of phonological encoding in speech production. Psycholinguistic studies of speech errors have found that conso-

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[16] All of these are described in §2.4.4 and §2.4.7 above. Walker (2000a) also appeals to the same analysis to account for obstruent voicing dissimilation in Gothic (Thurneysen's Law), but this will be ignored here.

[17] As mentioned in chapter 1, the relationship between Rose & Walker (2004) and the present study is a somewhat complex one. It was not until the final stages of the dissertation which underlies this monograph (Hansson 2001b) that I became aware of Rose & Walker's broader typological work (through the 2001 manuscript version of their 2004 *Language* article). The generalized ABC analysis that is developed in Hansson (2001b), and which has been left largely intact here, thus constitutes an independent extension of Walker's earlier work (Walker 2000a, 2000c, 2001), carried out in parallel to that laid out in Rose & Walker (2004). In the published version of their article, Rose & Walker (2004) incorporate various cases drawn from Hansson (2001b) into their typological overview, and discuss certain analytical and empirical issues that were first brought up in that work. Conversely, the present revised and expanded version of the Hansson (2001b) study reflects and draws upon Rose & Walker's work in many respects (as does the author's other recent work in this area).

nants are more likely to interact in slips of the tongue if they share a large number of phonological properties (Nooteboom 1969, MacKay 1970, Fromkin 1971, Shattuck-Hufnagel & Klatt 1979, Frisch 1996). In neural network models of speech production (Dell 1984, 1986, Stemberger 1985), this effect falls out from spreading activation. In the case of two consonants that share a large number of features, there is a great deal of overlap in the neurons activated for C_1 and C_2, and thus a greater likelihood that the activation associated with one of the two will interfere with the execution of the other. The greater the overlap, the greater the potential for interference effects (such as slips of the tongue).

From the point of view of the phonological grammar, Walker (2000a, 2000c, 2001) interprets these psycholinguistic findings as support for the notion that speakers construct a relation between similar segments in the phonological output representation. This relation is assumed to be one of correspondence, henceforth referred to as *CC correspondence* (as distinct from IO or BR correspondence). Rather than assume that correspondence between similar consonants is automatic (as it is for Input-Output or Base-Reduplicant correspondence), Walker suggests that the very presence of a correspondence relation between output consonants is regulated by ranked and violable constraints. To this end, she proposes a new family of correspondence-inducing constraints, CORR-C↔C, defined by the schema given in (10):

(10) CORR-C↔C (cited after Rose & Walker 2004:491)

Let *S* be an output string of segments and let C_i , C_j be segments that share a specified set of features *F*. If C_i , $C_j \in S$, then C_i is in a relation with C_j ; that is, C_i and C_j are correspondents of one another

Walker notes that relative similarity plays a role not only in speech errors, but also in various kinds of phonological agreement phenomena involving consonants. In Kera, for example, voicing agreement appears to hold only between stops (neither fricatives nor sonorants participate; but see §2.4.7). In Ngbaka, voicing agreement and nasal agreement are both restricted to obstruents that agree in place of articulation. This is taken to suggest that the demand for a correspondence relation is stronger the more similar C_i and C_j are. This implication is encoded in formal terms by arraying CORR-C↔C constraints in similarity-based hierarchies. The fixed rankings in (11) show a portion of such a hierarchy that is relevant for the voicing agreement observed in Ngbaka:

(11) Similarity-based hierarchy of CORR-C↔C constraints (Walker 2001)

CORR-T↔T >> CORR-T↔D >> CORR-K↔D >> …

The topmost constraint in (11), CORR-T↔T, forces a correspondence relation between pairs of identical oral stops (e.g. $[p_x \ldots p_x]$, $[d_y \ldots d_y]$, $[g_z \ldots g_z]$). (CC correspondence relations are indicated by subscript indices). That is, in the case of CORR-T↔T the term *F* in the schematic definition in (10) stands for the set [–sonorant, –continuant, –nasal, αPlace, βvoice].

CORR-T↔D, the second constraint in (11), induces correspondence between pairs of oral stops that differ at most in [voice], but agree in all other features (including [Place]). These include [p_x…b_x], [g_y…k_y], [d_z…t_z] etc., as well as fully identical-stop pairs such as [p_x…p_x], etc.[18] Finally, CORR-K↔D requires correspondence between stops that differ at most in [voice] *and* [Place] simultaneously ([k_x…d_x], [g_y…p_y], [b_z…t_z], etc.), in addition to the segment pairs affected by the two higher-ranked constraints. In short, CORR-T↔T singles out pairs of identical stops, CORR-T↔D picks out all pairs of homorganic stops (including identical ones) and CORR-K↔D refers to any pairs of stops (homorganic and heterorganic alike). The ranking in (11) thus reflects an subset relation among the natural classes to which the individual constraints refer.

The CORR-C↔C constraints do nothing more than establish an abstract CC correspondence relation; they do not in and of themselves enforce identity, or agreement in some feature [F], between C_i and C_j. That is the responsibility of IDENT[F]-CC constraints. In the case of voicing agreement, as in Ngbaka or Kera, the relevant constraint is IDENT[voice]-CC, defined along the lines of (12).

(12) IDENT[voice]-CC (cf. Rose & Walker 2004:492)

Let C_i be a consonant in the output and C_j be any correspondent of C_i in the output.
If C_i is [αvoice], then C_j is [αvoice].

Voicing harmony—construed as voicing agreement under CC correspondence—is forced when the relevant CORR-C↔C constraint(s) and IDENT[voice]-CC both outrank faithfulness to input [voice] specifications (IDENT[voice]-IO). The ranking responsible for the static pattern of morpheme-internal voicing harmony in Ngbaka is illustrated by the example in (13). A (hypothetical) disharmonic input /dota/ surfaces as harmonized [tota] (or, alternatively, as [doda]).[19]

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[18] Note that the order of segments is irrelevant here; CORR-T↔D demands correspondence in [g_y…k_y] no less than in [k_y…g_y]. More complicated cases, where directionality is involved, are discussed later in this chapter.

[19] The candidate [$d_{1,x}$o$d_{2,x}$a] is omitted from (13) for simplicity. It would fare exactly the same as the winner (13c) on the constraints considered here. As we are dealing with a static co-occurrence restriction on morphemes in this case, it is immaterial whether a hypothetical input /dota/ gets 'repaired' to [tota] or to [doda]; both are perfectly acceptable output strings in Ngbaka. The decision might fall to positional IO faithfulness (giving priority to preserving the [+voice] specification of the word-initial /d/), or to a markedness constraint like *OBSVOI (that is, *[–sonorant, +voice]) favoring [t] over [d] in outputs.

(13) Ngbaka: Voicing harmony between homorganic stops

$/d_1ot_2a/$	ID[voi]-CC	CORR-T↔T	CORR-T↔D	ID[voi]-IO	CORR-K↔D
a. $d_{1,x}ot_{2,y}a$			*!		*
b. $d_{1,x}ot_{2,x}a$	*!				
c. ☞ $t_{1,x}ot_{2,x}a$				*	
d. $t_{1,x}ot_{2,y}a$		*!	*	*	*

In the above tableau, IO correspondence relations are indicated with subscript digits and CC correspondence ones with subscript letters (“x”, “y”). Of the candidates shown here, (13a) and (13b) are faithful to all input [voice] specifications, whereas in (13c–d), the input /d/ surfaces unfaithfully as output [t]. The difference between (13a) and (13b) lies in the CC correspondence relations; the [d] and [t] stand in correspondence in (13b) but not in (13a). The non-faithful candidates (13c–d) differ from each other in the same way. Finally, note the implicational relationship between the hierarchically-ranked CORR-C↔C constraints. Violating CORR-T↔T entails also violating CORR-T↔D (13d), and violating CORR-T↔D in turn entails violating CORR-K↔D (13a, d). The reason is that any segment pair that fits the structural description of CORR-T↔T ([d…d], [t…t], [g…g]) will also fit that of CORR-T↔D (which *also* encompasses pairs like [d…t], [t…d], [g…k]), and so forth.

The ranking CORR-T↔D >> IDENT[voice]-IO means that homorganic stops will correspond to each other, even at the expense of altering underlying [voice] specifications. Consequently (13b) and (13d) are both better than the candidates that lack CC correspondence, (13a) and (13c). The choice between (13b) and (13d) is decided by the ranking IDENT[voice]-CC >> IDENT[voice]-IO. In situations a given output segment (in this case C_1) has both a CC-correspondent in the output (the [t] to its right) and an IO-correspondent (the underlying /d/), agreement in [voice] with the former is more important than with the latter, given the ranking shown here. The end result is that homorganic output stops are forced to agree in voicing, even if they disagree in the input.

On the other hand, as shown in the tableau in (14), the same ranking does not force agreement between heterorganic stops. A hypothetical input /duka/ thus surfaces faithfully, despite being ‘disharmonic’ in terms of voicing agreement.

(14) Ngbaka: No voicing harmony between homorganic stops

/d_1uk_2a/	IDENT[voi]-CC	CORR-T↔T	CORR-T↔D	IDENT[voi]-IO	CORR-K↔D
a. ☞ $d_{1,x}uk_{2,y}a$					*
b. $d_{1,x}uk_{2,x}a$	*!				
c. $t_{1,x}uk_{2,x}a$				*!	
d. $t_{1,x}uk_{2,y}a$				*!	*

In this case, the (highest-ranking) relevant CORR-C↔C constraint is CORR-K↔D, since the two stops disagree in place of articulation. As in the previous case, candidates (14b) and (14c) include a CC correspondence relation which links the consonants C_1 and C_2. As before, the ranking IDENT[voice]-CC >> IDENT[voice]-IO means that, if the choice were to lie between (14b) and (14c), the latter would win, since disagreement between CC correspondents is more costly than between IO correspondents. But there is an even less costly alternative, namely to sacrifice the CC correspondence relation itself. For heterorganic stops, IO faithfulness outranks the demand for CC correspondence (IDENT[voice]-IO >> CORR-K↔D), and therefore the faithfully disharmonic (14a) does better than the unfaithfully harmonic (14c). Note that undominated IDENT[voice]-CC is vacuously satisfied in (14a), as there is no CC correspondence relation for that constraint to evaluate.

In sum, the sensitivity to relative similarity is captured in the ABC model by adopting a similarity-based hierarchy of CORR-C↔C constraints. The interpolation of IO faithfulness constraints with this hierarchy establishes where a given language sets the similarity threshold, such that only those pairs of co-occurring segments that fall above this threshold are 'visible' to the constraints that require agreement (IDENT[F]-CC). For example, recall that Kera voicing harmony holds between heterorganic plosives as well as homorganic ones (/dʒàr-ká/ 'colorful (fem.)' → [dʒàrgá]). This difference between Ngbaka and Kera would be captured by assuming that in Kera, faithfulness to input [voice] specifications (IDENT[voice]-IO) is ranked below the constraint CORR-K↔D, rather than above it as in Ngbaka.

This concludes our somewhat sketchy description of the ABC model developed in Walker (2000a, 2000c, 2001) and elaborated in Rose & Walker (2004). Some details have been glossed over here for reasons of economy. The generalized OT analysis of consonant harmony that is laid out in the remainder of this chapter (and explored further in chapter 5) is an extension of this model. It will therefore be more useful to discuss specific details as they arise. Where ideas or formal devices are borrowed wholesale from the work of Rose and/or Walker, this is noted accordingly.

4.2. The Basic Architecture: String-Internal Correspondence and Agreement

This section outlines the fundamental ingredients of the generalized OT analysis of consonant harmony proposed in this work. The analysis builds on the ABC model (Walker 2000a, 2000c, 2001, Rose & Walker 2004) outlined in the previous section, but differs in certain non-trivial details, such as with respect to the (a)symmetry of the correspondence relation and the formal properties of the agreement-enforcing constraints.

4.2.1. The CORR-C↔C Constraint Family

I will assume, following the ABC model described in §4.1.2 above, that long-distance consonant assimilation results from the combined efforts of two distinct types of constraints. On this approach, the task of enforcing long-distance agreement is divided into two components. Firstly, a correspondence relation is established between two segments in the output string, provided that they are sufficiently similar to one another. This is the responsibility of the CORR-C↔C constraints. Secondly, those output segments that come to stand in such a correspondence relation to one another are evaluated as to whether they agree in some feature [F]: the harmonizing property. This task is accomplished by correspondence constraints of the type IDENT[F]-CC, which are confined to string-internal correspondents (just as IDENT[F]-IO evaluates only input-output correspondent pairs, IDENT[F]-BR only base-reduplicant correspondent pairs, and so forth).

This section explains in greater detail the nature of the CORR-C↔C constraints and of the correspondence relation they establish. We first consider the dependence of correspondence on relative similarity and the distance separating the trigger-target pair (§4.2.1.1). We then take up the question of symmetric vs. asymmetric correspondence relations, and how this distinction may be relevant for the understanding of directionality effects in consonant harmony systems (§4.2.1.2). Based on the findings reported in §3.1 above, a somewhat more restrictive view of string-internal correspondence is taken than that advocated in other works using the ABC model.

4.2.1.1. Scaling of CORR-C↔C by Similarity and Distance

Following the ABC model as laid out by Walker (2000a, 2000c, 2001), I assume that the CORR-C↔C constraints are relativized with respect not only to the similarity of the interacting consonants but also to the distance separating them.[20] Looking first at relative similarity, CORR-C↔C constraints arrange themselves in a (partially) fixed ranking, essentially forming an implicational hierarchy. A demand for correspondence between segments that differ in

[20] In Rose & Walker's (2004) revised version of the ABC model, the factor of relative trigger-target distance is dealt with somewhat differently, by means of a single PROXIMITY constraint; see below for discussion.

features [F, G, H] entails a (stronger) demand for correspondence between those that differ only in [F, G] (or only in [F, H], or in [G, H]), and a demand for correspondence between segments differing in [F, G] in turn entails an even stronger demand for correspondence between those differing only in [F] (or only in [G]). An illustrative example is shown in (15), adapted from Walker (2000c) with minor changes (see also Rose & Walker 2004). In order to avoid accidental reference to the linear order of the interacting consonants, I use labels like CORR-[nas] and CORR-[nas, Place] in place of Walker's CORR-N↔D, CORR-N↔B, etc.

(15) Similarity-scaling in terms of fixed CORR-C↔C hierarchies

a. CORR-[F_1, …, F_n] (definition, first pass):
Given an output string *S*, and consonants C_i, $C_j \in S$, where $C_i < C_j$ (C_i precedes C_j) and C_i and C_j differ at most in the features [F_1, …, F_n], then a correspondence relation must be present between C_i and C_j.

b. CORR-[nas] >> {CORR-[nas, Pl], CORR-[nas, voi]} >> CORR-[nas, Pl, voi], …

Concretely, the effect of the hierarchy in (15b) is that the establishment of a correspondence relation between consonants differing only in nasality ([m…b]) is enforced more strictly than for pairs differing in nasality and place of articulation ([m…d], [b…n]) or nasality and voicing ([t…m], [n…k]), and so on. (Recall that we are here dealing merely with enforcing the *presence* of an abstract correspondence relation between the two consonants; how perfect or imperfect that correspondence is, with respect to some particular feature, is an entirely different matter.)

Note that, as stated in (15), there is no fixed ranking between CORR-[nasal, Place] and CORR-[nasal, voice], since there is no intrinsic implicational relationship between the two. This does of course not entail that their relative ranking is indeterminate or irrelevant in a given language. For example, the ABC analysis of Bantu nasal consonant harmony in Walker (2000c) and Rose & Walker (2004) crucially relies on a ranking CORR-[nasal, Place] >> CORR-[nasal, voice]: heterorganic nasals and voiced stops correspond (and harmonize in [±nasal]), whereas homorganic nasals and voiceless stops do not interact. Since the hierarchy of CORR-C↔C constraints encodes relative similarity, it might be said that the phonology of these languages assesses a pair like [m…d] to be more similar than a pair like [m…p]. For the time being, I will leave it as an open question whether this is a matter of *extrinsic* (and thus language-specific) constraint ranking, or whether the ranking is partly *intrinsic*, a consequence of some universal and deterministic similarity metric.[21] The issue of relative similarity and its precise definition will be revisited in §5.3.2 below.

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[21] Note that even if universal and deterministic, such a similarity metric may still be sensitive to language-specific properties such as the structure of the segment inventory or redundancy relations between feature specifications. An excellent example of this is the natural classes model of similarity (Frisch 1996, Frisch et al. 2004); see §5.3.2 for discussion.

In addition to similarity, many consonant harmony systems display some degree of sensitivity to the distance between the trigger and target segments, as was discussed earlier (see §3.2.2.3). For example, many Bantu languages restrict nasal consonant harmony to segments separated by at most a single vowel (short or long), a pattern referred to as 'transvocalic' consonant harmony in §2.4.4 above. Given the restrictions on syllable structure that the languages in question happen to follow, the restriction can be restated as limiting harmony to segments that are onsets of adjacent syllables. Thus, in languages such as Lamba, nasal consonant harmony applies in contexts like /…N̲V.D̲V…/, but not in /…N̲V.CV.D̲V…/. Similar proximity effects can be observed in various other types of consonant harmony, including many sibilant harmony systems. Drawing on proposals by Suzuki (1998), Walker (2000c) suggests that proximity effects be captured by relativizing the CORR-C↔C constraints with respect to the distance separating C_i and C_j.[22] This general strategy will be adopted here. For each CORR-C↔C constraint, such proximity scaling then yields fixed hierarchies of the sort shown in (16):

(16) Proximity scaling by fixed CORR-C↔C hierarchies

$$\text{CORR-[F, G]}_{CC} >> \text{CORR-[F, G]}_{C\text{-}v\text{-}C} >> \text{CORR-[F, G]}_{C\text{-}\infty\text{-}C}$$

The ranking in (16) shows the proximity scaling of one particular constraint, CORR-[F, G], a constraint requiring that a correspondence relation be present between co-occurring consonants that differ at most in one or both of the features [F] and [G]. The highest-ranked version of this constraint, CORR-$[F, G]_{CC}$, requires correspondence between such a consonant pair under direct adjacency (the smallest conceivable distance). The lower-ranked version CORR-$[F, G]_{C\text{-}v\text{-}C}$ requires correspondence between such pairs if they are separated by no more than a vowel (long or short).[23] It thus encompasses not only adjacent consonants (clusters) but also the onset and coda of a C̲V(V)C̲ syllable, or the onsets of adjacent syllables, such as in a …C̲V(V).C̲V… sequence. The lowest-ranked version CORR-$[F, G]_{C\text{-}\infty\text{-}C}$ has no proximity restrictions at all, requiring correspondence between C_i and C_j no matter how far apart they are in the output string.

It is worth emphasizing that the similarity hierarchy in (15) and the proximity hierarchy in (16) are entirely independent of one another. For each similarity threshold, the relevant CORR-C↔C constraint 'expands' into its own hierarchy of proximity-scaled versions of that

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[22] This aspect of Walker's analysis was present in the original presentation of her (2000c) conference paper, thought it has been omitted in the published version; it is also hinted at in Walker (2000a, 2001).

[23] Whether intervening glides would be treated as equivalent to vowels in this respect (being [–consonantal]), for example in …C̲GVC̲… sequences, is an interesting question which I will not attempt to address here. The criterion which appears to provide the best empirical fit is that the two consonants be separated by no more than one *nucleus*.

same constraint. In other words, just as CORR-[F] yields the entire hierarchy in (16) above, so does the lower-ranked CORR-[F, G] give rise to its own hierarchy: CORR-[F, G]$_{CC}$ >> CORR-[F, G]$_{C\text{-}v\text{-}C}$ >> CORR-[F, G]$_{C\text{-}\infty\text{-}C}$. Likewise, within any given proximity level, such as 'transvocalic' C-v-C (where C_i and C_j are separated by at most a vowel), the full similarity hierarchy is respected. In effect: CORR-[F]$_{C\text{-}v\text{-}C}$ >> CORR-[F, G]$_{C\text{-}v\text{-}C}$ >> CORR-[F, G, H]$_{C\text{-}v\text{-}C}$, and so on.

It should also be pointed out that since the similarity and proximity hierarchies are essentially orthogonal, the specific way in which they are interleaved into a single constraint ranking can vary from language to language. As an example, take four CORR-C↔C constraints, each specified for a certain similarity threshold and a certain proximity threshold: CORR-[F]$_{C\text{-}v\text{-}C}$, CORR-[F]$_{C\text{-}\infty\text{-}C}$, CORR-[F, G]$_{C\text{-}v\text{-}C}$ and CORR-[F, G]$_{C\text{-}\infty\text{-}C}$. The possible ranking relationships between these four are shown in (17). The proximity hierarchy dictates that a fixed ranking hold between the two CORR-[F] constraints, and likewise between the CORR-[F, G] constraints (17a). The similarity hierarchy in turn demands a fixed ranking between the two 'transvocalic' constraints, as well as between the two 'long-range' constraints (17b). But note that the relative ranking between CORR-[F]$_{C\text{-}\infty\text{-}C}$ and CORR-[F,G]$_{C\text{-}v\text{-}C}$ is not fixed (17c). Based on similarity criteria alone, the former would have priority, as it applies to a narrower set of consonants (those differing at most in [F], as opposed to ones potentially differing in [G] as well). Based on proximity alone, however, the latter would have priority, since it applies to consonant pairs that are closer to one another. There is thus room for two different rankings, depending on which factor is given higher priority in the grammar in question, similarity or distance.

(17) Interplay of similarity-scaling and proximity-scaling

a. Fixed rankings due to proximity hierarchy:
   CORR-[F]$_{C\text{-}v\text{-}C}$ >> CORR-[F]$_{C\text{-}\infty\text{-}C}$
   CORR-[F, G]$_{C\text{-}v\text{-}C}$ >> CORR-[F, G]$_{C\text{-}\infty\text{-}C}$
b. Fixed rankings due to similarity hierarchy:
   CORR-[F]$_{C\text{-}v\text{-}C}$ >> CORR-[F, G]$_{C\text{-}v\text{-}C}$
   CORR-[F]$_{C\text{-}\infty\text{-}C}$ >> CORR-[F, G]$_{C\text{-}\infty\text{-}C}$
c. Constraint pair subject to *language-particular* ranking:
   {CORR-[F,G]$_{C\text{-}v\text{-}C}$, CORR-[F]$_{C\text{-}\infty\text{-}C}$}

There is no *a priori* reason to assume that only one of the rankings allowed by (17c) is possible. For example, consonant harmony in Language A might be subject to a very strict similarity threshold without showing any clear distance-related effects (i.e. being unbounded). In Language B, by contrast, the very same type of harmony might be subject to a stricter proximity threshold (being 'transvocalic') but be *less* stringent on the similarity requirements on eligible trigger-target consonant pairs than Language A. In terms of the alternative rankings that are consistent with (17), Language A would thus have the ranking CORR-[F]$_{C\text{-}\infty\text{-}C}$ >> IO-

FAITH >> CORR-[F, G]$_{C\text{-}v\text{-}C}$ whereas language B would have the ranking CORR-[F,G]$_{C\text{-}v\text{-}C}$ >> IO-FAITH >> CORR-[F]$_{C\text{-}\infty\text{-}C}$.

It is worth dwelling on the particular proximity levels that are encoded in the hierarchy in (16). In practice, this gives rise to a three-way categorization in terms of the sets of contexts in which correspondence—and hence featural agreement (that is, assimilation)—can be enforced for segments meeting the relevant similarity criteria:

- agreement only under direct adjacency, …$\underline{C}_i\underline{C}_j$… (local assimilation in *clusters*)
- agreement in transvocalic …$\underline{C}_i$V(ː)$\underline{C}_j$… sequences (and under direct adjacency)
- unbounded agreement, including …$\underline{C}_i$…C…$\underline{C}_j$… (as well as transvocalic and direct-adjacency contexts)

Needless to say, the first of these types would not qualify as an instance of 'consonant harmony' as it has been defined in this work (see §1.1 above), as only local assimilation is involved. It appears that the other two types are the only ones which emerge from the typological survey in chapter 2: consonant harmony is either strictly transvocalic—such that it is interrupted (blocked) by any intervening consonant—or it is completely unbounded. No intermediate levels of proximity restrictions appear to exist. Moreover, there is no evidence that prosodic structure (syllable affiliation, foot structure) ever plays a direct role in adjudicating proximity restrictions, such as requiring that C_i and C_j be located within the same foot (or in adjacent feet).

Rose & Walker (2004) approach the transvocalic vs. unbounded dichotomy in a rather different way. Instead of encoding proximity thresholds in the individual CORR-C↔C constraints as in (16), they propose a single monolithic constraint PROXIMITY, which demands that correspondent segments be located 'in adjacent syllables'. That is, no syllable may intervene between C_i and C_j (such that neither C_i nor C_j belongs to that syllable). While this is an attractive approach in some respects, the syllable-adjacency approach to proximity restrictions makes somewhat problematic empirical predictions, as was discussed in some detail in §3.2.2.3 above. For this reason that approach is rejected here. However, much is admittedly unclear about the nature of the 'transvocalic' vs. 'unbounded' dichotomy (and the extent to which it might implicate syllable structure and syllabification), and this is an issue which certainly merits further investigation.

4.2.1.2. Asymmetric C-C Correspondence and Directionality Effects

Thus far our definition of CORR-C↔C constraints, and their scaling based on relative trigger-target similarity and proximity, has been largely identical to that assumed by Walker (2000a, 2000c, 2001) and Rose & Walker (2004) (except for the latter's treatment of proximity restrictions, as discussed above). Certain formal aspects of the correspondence relation imposed by CORR-C↔C constraints have yet to be addressed, however, concerning the notion of symmetric vs. asymmetric correspondence relations. As was noted in §3.1 above, numerous consonant harmony systems obey a strict directionality, typically anticipatory (regressive, right-to-left), which cannot be reduced to other factors such as cyclicity ('inside-out' effects) or the dominant status of a particular feature value. If consonant harmony is indeed a matter of agreement under correspondence, this suggests that directional consonant harmony reflects a directional *asymmetry* in the correspondence relations involved.

This is the conclusion drawn by Walker (2000c) in her analysis of Yaka nasal consonant harmony, which appears to obey a strict perseveratory (progressive, left-to-right) directionality: /m…d/ → [m…n], but not /d…m/ ↛ [n…m]. She captures this by stipulating that the CC correspondence relation be asymmetric in Yaka, i.e. from C_1 to C_2, or $C_1 \rightarrow C_2$. This means that properties of C_1 can influence C_2, but there is no direct requirement for C_1 to take after C_2 in any way. In particular, the constraint ultimately responsible for enforcing the agreement, IDENT[+nas]-CC, is violated only by the sequence [n_x…d_x] but not by its mirror image [d_x…n_x]. Under the assumption that C_2 is a correspondent of C_1 ($C_1 \rightarrow C_2$), but not vice versa, the IDENT-CC constraint simply requires that if C_1 is [+nasal], then C_2 must also be [+nasal]. It has nothing to say about cases where C_1 is [–nasal], regardless of whether C_2 is [+nasal] or not. As C_1 is not a correspondent of C_2, a [+nasal] specification on the latter cannot influence the former.

In her analysis of obstruent voicing harmony in Kera, on the other hand, where [+voice] is transmitted bidirectionally from the root to prefixes and suffixes, Walker (2000a, 2001) concludes that the CC correspondence in this case is a symmetric relation, $C_1 \leftrightarrow C_2$. Indeed, this is how CC correspondence was defined in our discussion of the ABC model in §4.1.3 above. We may ask whether it is necessary to assume that string-internal correspondence be parameterized on a language-particular basis in this way. Do some languages have symmetric (non-directional) CC correspondence and others asymmetric (directional) CC correspondence? In the latter case, do languages have a further "choice" between anticipatory (left-to-right) correspondence $C_1 \rightarrow C_2$ and perseveratory (right-to-left) correspondence $C_1 \leftarrow C_2$? More importantly, how might this issue relate to the empirical generalizations about directionality effects in consonant harmony systems that were reported in §3.1? Before answering these questions, let us briefly consider the implications of a distinction between symmetric vs. asymmetric correspondence relations.

In this context, it is useful to step back and briefly reconsider the most basic and least contentious dimension of correspondence: that between input and output. In the most intuitive sense, Input-Output (IO) correspondence is a *symmetric* relation relating underlying and surface representations. Individual correspondence constraints (MAX, DEP, IDENT[F], LINEARITY, CONTIGUITY, etc.; McCarthy & Prince 1995) have the role of ensuring that these two representations be as similar to each other as possible. In practice, evaluating an input-output pair is always a matter of evaluating the output against the input, rather than vice versa: the Input provides a fixed standard of comparison, and the extent to which each candidate output deviates from this standard is assessed.[24] In this sense, there is a certain asymmetry built into the evaluation of IO correspondence, although this asymmetry could be argued to be purely epiphenomenal. But there are other reasons why IO correspondence cannot be considered entirely symmetric. In order to see why this is so, consider constraints of the IDENT[F] family. Under one popular point of view (following the original proposal by McCarthy & Prince 1995), the constraint IDENT[F] penalizes any kind of I/O mismatch with respect to feature [F], both the one depicted in (18a) and the one in (18b). From the point of view of IDENT[F], the IO correspondence relation is thus entirely symmetric. It penalizes any I↔O mapping where an [αF] segment in one representation has a [–αF] correspondent in the other representation.

(18) IO mappings violating IDENT[F] (symmetric correspondence):

a.	*Input:*	[+F]	b.	*Input:*	[–F]
		|			|
	Output:	[–F]		*Output:*	[+F]
	(i.e. [+F] → [–F])			(i.e. [–F] → [+F])	

Now consider the constraints MAX and DEP, which prohibit deletion and epenthesis, respectively. Each of these penalizes a state of affairs whereby a segment in one representation is absent from the other. This is represented schematically in (19), where the segment lacking a correspondent is indicated as *S*.

(19) IO mappings violating MAX or DEP ('symmetric' correspondence?!)

a.	MAX violation:		b.	DEP violation:	
	Input:	*S*		*Input:*	Ø
		|			|
	Output:	Ø		*Output:*	*S*
	(i.e. *S* → Ø = deletion)			(i.e. Ø → *S* = epenthesis)	

If IO correspondence were a truly symmetrical relation, the configurations in (19a) and (19b) would have to be penalized by a *single* constraint (which we might call 'HAVECORRESPONDENT'), just as it is the job of the single constraint IDENT[F] to penalize both (19a) and

[24] An exception is Lexicon Optimization, where the learner establishes an input (lexical representation) based on an actual output representation (Prince & Smolensky 1993; cf. Inkelas 1995). This is irrelevant for the purposes of the present discussion, however. Another possible exception is allomorph selection, where the selection of the optimal output candidate involves the parallel selection of one of two (or possibly more) alternative input representations (Mester 1994, Kager 1996, Dolbey 1996).

(19b). This is not a matter of 'design' choice. It is impossible in principle to define MAX as distinct from DEP without making explicit reference to the terms 'Input' and 'Output'; that is, without explicitly distinguishing between the configurations X↔Y and Y↔X. This entails accepting that the relation indicated by the '↔' symbol is *not* a fully symmetric one. The same, of course, would apply in the domain of Base-Reduplicant (BR) correspondence, and in all other domains involving correspondence mappings. Without acknowledging the inherent asymmetry of the BR correspondence relation, we cannot define MAX-BR and DEP-BR as distinct constraints.

It is quite clear that conflating MAX and DEP into a single constraint is not feasible on practical grounds. This would make it impossible to distinguish between deletion and epenthesis as alternative repair strategies and to capture language-specific choices among such strategies. But it cannot be emphasized enough that the very notion of MAX and DEP as separate and independent constraints presupposes a certain asymmetry. To define these two constraints in a general way, one would appear to need to designate one of the two domains as somehow 'primary' (Input, Base of Reduplication, Base of Affixation, etc.) and the other as 'secondary' (Output, Reduplicant, Affixed Form, etc.). A MAX constraint is then violated when a segment in a primary domain lacks a counterpart in the relevant secondary domain, and vice versa for DEP constraints.

A more straightforward (but equivalent) way of conceptualizing this asymmetry is to assume that the correspondence relation *itself* is asymmetric.[25] From this perspective, the correspondence holding between a "primary" domain A (e.g., the Input) and a "secondary" domain B (e.g., the Output) can be represented as A→B. Furthermore, the meaning and use of the terms "correspondent of" and "correspond to" needs to be made very precise. Under the view of asymmetric correspondence adopted here (A→B), *B corresponds to A* but not vice versa; likewise, *B is a correspondent of A* but not vice versa. In other words, output segments correspond to input segments, reduplicant segments to base segments, and so forth. However, it is then incorrect to say that an input segment (A) "corresponds to" or "is a correspondent of" an output segment (B). The directionality of the arrow in the mapping A→B signifies the directionality of the implicational relationship holding between A and B: individual faithfulness constraints require that B "take after" A with respect to some properties, never vice versa (e.g., *if* A is [αF], *then* B is [αF]).

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[25] Something along these lines is in fact built into the formalization of Correspondence Theory by McCarthy & Prince (1995), where correspondence is defined as a *relation* $\mathfrak{R}$ from one representation (string, ordered set of segments), S_1, to another, S_2. For example, there is an explicit distinction drawn between the *domain* of the $\mathfrak{R}$ relation (where Domain($\mathfrak{R}$) = the set of all elements in S_1 for which a correspondent exists in S_2) and its *range* (where Range($\mathfrak{R}$) = the set of all elements in S_2 for which a correspondent exists in S_1). It is clear, then, that the configurations $x\mathfrak{R}y$ and $y\mathfrak{R}x$ are not equivalent, and (certain) correspondence constraints will treat the two differently.

Let us now revisit the definition of IDENT[F] constraints, as these are obviously the ones involved in enforcing harmony (i.e. agreement under CC correspondence). In (18) it was assumed that IDENT[F] constraints are symmetric, penalizing any kind of [F]-value mismatch between the correspondence pair. Thus both (18a) and (18b) count as violations of the single constraint IDENT[F]. However, a growing body of evidence has been accumulating that the symmetric IDENT[F] model is inadequate. On the one hand, languages may tolerate an [αF]→[–αF] mapping better than the reverse mapping [–αF]→[αF] (for example, allowing unfaithful input-to-output mappings involving [–nasal] → [+nasal] while at the same time prohibiting [+nasal] → [–nasal]). Such effects have been to make IDENT[F] constraints refer to particular feature *values*, such that IDENT[+F] and IDENT[–F] are independent constraints (see McCarthy & Prince 1995, 1999, Pater 1999, among others). On the other hand, there are phenomena which appear to involve individual (privative) features acting as free autosegments. This has been interpreted as evidence that features themselves stand in a correspondence relation across domains, evaluated by MAX[F] and DEP[F] constraints (see, e.g., Pulleyblank 1996, Causley 1997, Myers 1997, Lombardi 1998, 2001). As enriched versions of the original symmetric-IDENT[F] model, both alternatives hinge on an asymmetric conception of the correspondence relation. For the purposes of the analysis of consonant harmony, the value-specific IDENT[αF] approach and the MAX[F]/DEP[F] approach are more or less equivalent in terms of their implications. However, the latter requires that a series of additional issues be addressed: binarity vs. privativity of specific features; spreading vs. feature insertion/deletion (spreading [F] from a neighboring segment violates IDENT[F] but not DEP[F]); "deletion" vs. "insertion" of association lines (paths between [F] elements and their segmental anchors); the possibility of floating features in the input or output; and so forth. For this reason, I will adopt the IDENT[αF] approach here for simplicity.[26]

Note that splitting IDENT[F] into the independent constraints IDENT[+F] and IDENT[–F] itself presupposes an asymmetric correspondence relation. The [F]-value mentioned in the constraint label refers to a specification in what was referred to as the "primary" domain above (Input, Base, etc.) and the constraint requires that this feature specification be preserved or matched in the "secondary" domain (Output, Reduplicant, etc.). This is illustrated schematically in (20).

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[26] For privative [F], a segment-based alternative to MAX[F]-IO/DEP[F]-IO is to distinguish between IDENT[F]-IO and IDENT[F]-OI; these are essentially equivalent to IDENT[+F]-IO and IDENT[–F]-IO, respectively. By the same nomenclature—seen also in CONTIGUITY-IO vs. CONTIGUITY-OI ("I-CONTIGUITY" vs. "O-CONTIGUITY"), and in UNIFORMITY-OI ("INTEGRITY", in contrast to UNIFORMITY-IO)—the constraint DEP-IO could really be renamed "MAX-OI", though to my knowledge no one has ever suggested this.

(20) IDENT[αF] under asymmetric IO correspondence (Input → Output):

a. IDENT[+F] violation:

Input:	[+F]
	|
Output:	[–F]

b. IDENT[–F] violation:

Input:	[–F]
	|
Output:	[+F]

If the IO correspondence relation were perfectly symmetric (I↔O rather than I→O), IDENT[+F] would be violated equally by (20a) *and* (20b), since both configuration involve a [+F] segment whose correspondent in the "other" domain is not [+F]. Likewise, IDENT[–F] would be violated by (20a) and (20b) alike, for the same reason. In short, the very distinction between IDENT[+F] and IDENT[–F] is meaningless unless asymmetric correspondence is assumed.

Finally, it should be emphasized that even though value-specific IDENT[+F] and IDENT[–F] presupposes an asymmetric correspondence relation, it is not the case that value-neutral IDENT[F] presupposes *symmetric* correspondence. Even though the correspondence mapping in (20) is asymmetric, I→O, both (20a) and (20b) violate IDENT[F], since this constraint merely requires that if a segment is [αF], then its correspondent must also be [αF] (regardless whether α stands for + or –). The end result is thus exactly the same as in (18), where a symmetric correspondence relation was assumed (I↔O). Asymmetric correspondence is thus equally compatible with value-neutral IDENT[F] and value-specific IDENT[+F] vs. IDENT[–F].

The purpose of this rather lengthy excursus has been to show that interpreting the CC correspondence relation (as established by CORR-C↔C constraints) as being *asymmetric* is neither an ad hoc move nor a radical departure from current practice in Correspondence Theory. However, this still does not answer the questions raised earlier. Is it the case that CC correspondence is symmetric (C_1↔C_2) in some languages but asymmetric (C_1→C_2 or C_1←C_2) in others? If CC correspondence is asymmetric in at least some languages, can it vary between left-to-right (C_1→C_2) and right-to-left (C_1←C_2) on a language-specific basis? Since the manifestation of asymmetric correspondence is *directionality* of assimilation, this brings us back to the issue of what directionality patterns are attested in consonant harmony systems.

As discussed in the preceding chapter (§3.1), a detailed typological survey of consonant harmony systems revealed very clear empirical generalizations regarding directionality effects. It was found that consonant harmony always obeys one of two patterns: it is either *cyclic* or *anticipatory* (regressive). In other words, consonant harmony can either follow morphological structure, applying in an "inside-out" fashion (stem-to-affix), or it can be insensitive to morphology, in which case it is always strictly regressive (right-to-left). There is thus a clear cross-linguistic preference for anticipatory assimilation, other things being equal (those "other things" in this case being morphological constituent structure). Attested counter-examples—systems that appear to exhibit strictly *progressive* harmony regardless of morphology—are at best extremely few. It would thus seem desirable to build the bias towards anticipatory assimilation directly into our generalized analysis of consonant harmony.

If we assume (following Walker 2000c) that the proper way to capture directionality effects is to assume an asymmetric correspondence relation, then strict right-to-left directionality translates into strict right-to-left correspondence. In a string [$\ldots C_1 \ldots C_2 \ldots$] (where the pair C_1/C_2 meets the relevant similarity and proximity criteria), the correspondence relation is thus $C_1 \leftarrow C_2$: that is, C_1 corresponds to C_2, but not vice versa. In other words, C_1 is a correspondent of C_2, but C_2 is *not* a correspondent of C_1. This becomes relevant when we consider the IDENT-CC constraints that evaluate the $C_1 \leftarrow C_2$ mapping, as will be discussed in more detail in the next section. A constraint IDENT[+F]-CC, when applied to such an asymmetric $C_1 \leftarrow C_2$ relation, will be violated by the sequence C_1[–F]…C_2[+F], but it will have nothing to say about the pair C_1[+F]…C_2[–F]. The end result, provided that IDENT[+F]-CC has its way, is that [+F] is "transmitted" from C_2 to C_1 in [–F]…[+F] sequences (anticipatory/right-to-left harmony), but not from C_1 to C_2 in [+F]…[–F] sequences (no perseveratory/left-to-right harmony).[27] The directionality problems raised by *featurally symmetric* systems, where [+F] and [–F] alike trigger (anticipatory) assimilation, are taken up in §4.3.1 below.

In order to capture the cross-linguistic preference of anticipatory harmony, I will henceforth assume that this directionality is directly built into the definition of the correspondence relation that is established by the CORR-C↔C constraints. Revising the definition from (15a) above (and ignoring any restrictions on the maximal distance separating C_1 and C_2) we thus arrive at the following:

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[27] Rose & Walker (2004) deal with directionality in a somewhat different way (though the difference is more superficial than it might seem at first glance). They encode directionality not in the relation established by CORR-C↔C but in the individual IDENT[F]-CC constraints that evaluate CC correspondence. Their IDENT[F]-C_RC_L (with privative [F]) is equivalent to IDENT[+F]-CC in the analysis presented here: both constraints demand that if the consonant on the right ("C_R") is [(+)F], then the consonant on the left ("C_L") must also be [(+)F]. Conversely, their IDENT[F]-C_LC_R is equivalent to my IDENT[–F]-CC. The only directional systems Rose & Walker (2004) analyze in detail involve features that are plausibly privative. It is worth noting that in cases where the relevant feature is binary [±F], there is a certain redundancy in their approach. If IDENT-CC constraints *are not* relativized to specific feature values, then a constraint like IDENT[±F]-C_RC_L is identical to IDENT[±F]-C_LC_R in terms of its effects, such that the linear-precedence indices "R" and "L" are rendered meaningless. If they *are* relativized by feature value, then IDENT[+F]-C_RC_L and IDENT[–F]-C_LC_R are indistinguishable from one another, and so are IDENT[–F]-C_RC_L and IDENT[+F]-C_LC_R. In the present analysis, where all correspondence is assumed to be from "C_R" to "C_L", the former constraint pair is replaced by IDENT[+F]-CC and the latter pair by IDENT[–F]-CC.

(21) CORR-[F_1, …, F_n] (revised definition):

Given an output string *S* and two consonants C_i, $C_j \in S$, where

i. $C_i < C_j$ (C_i precedes C_j); and

ii. C_i and C_j differ at most in the set of features [F_1, …, F_n],

then a correspondence mapping must be present *from C_j to C_i* ($C_i \leftarrow C_j$) such that *C_i is a correspondent of C_j*.

Defining CC correspondence as a strictly anticipatory relation may seem an entirely ad hoc stipulation. However, there are two good reasons for adopting this view. One is the empirical observation that anticipatory assimilation is very clearly the default directionality for consonant harmony phenomena (barring any interference from morphological structure). The definition of consonant harmony as resulting from a right-to-left correspondence mapping is not so much stipulated as *inferred* from this observation.

The other, more persuasive argument for the asymmetric definition in (21) is that the anticipatory bias is grounded outside of formal phonological theory. A fundamental claim of the present study is that consonant harmony interactions are grounded in (that is, are motivated by, or arise from) the speech planning domain—the phonological encoding phase of speech production—and that they share many distinguishing properties with phonological speech errors. Several of the typological characteristics of consonant harmony systems fall out from this view: sensitivity to the relative similarity of the trigger-target pair, the inertness of any intervening segmental material, and the existence of a "palatal bias" effect in coronal harmony systems (see chapter 6). As it turns out, the bias toward *anticipatory* interaction is yet another trait which consonant harmony shares with speech errors.

Schwartz et al. (1994) and Dell et al. (1997) have found that, under normal circumstances, anticipatory errors (e.g., *cu**ff** of coffee*) are more frequent than perseveratory ones (e.g., *beef **n**eedle soup*), the former often outweighing the latter by a ratio of 2:1 or even 3:1. Dell et al. (1997) refer to this as the *general anticipatory effect*. Furthermore, it appears that under conditions where error rates are elevated, the proportion of perseveratory errors increases. It is a well-known fact that error rate is higher in less familiar, more difficult phrases. Schwartz et al. (1994) found a clear *anticipatory practice effect* in such cases, whereby practice not only reduced the overall error rate but also had a large effect on the anticipatory : perseveratory ratio. For the first practice block of difficult phrases such as *chef's sooty shoe soles*, anticipatory errors were in fact outweighed by perseveratory ones (the former constituting only 38% of the relevant errors), but by the eighth block, anticipations dominated (at 70%). This anticipatory practice effect was robustly replicated by Dell et al. (1997). Another related factor is speech rate. Dell (1990) found that the proportion of perseveratory errors increased as the available time for speaking decreased, that is, with increased speech rate; a similar speech-rate effect was found by Dell et al. (1997). Yet another finding reported by Schwartz et al. (1994) is that many aphasics' speech is characterized by a much higher proportion of perseveratory errors than non-aphasic speech. Finally, age appears to be a factor as well. Stemberger (1989) found that while adults' slips of the tongue were predominantly anticipatory, children tended to perseverate more, especially younger children (for age 2, the anticipation to perseveration ratio was approximately 2:3).

In sum, the generalization appears to be that, *other things being equal*, speech errors are vastly more likely to involve anticipatory influence (right-to-left interference) than perseveratory influence (left-to-right interference). Dell et al. (1997) derive this from the general properties of their theory of serial order in speech production (as implemented in a particular computational model):

> [A] theory of serial order in speech must satisfy a set of functional requirements: The system must activate the present, deactivate the past, and prepare to activate the future. […T]he general anticipatory effect follows from these functions, given certain assumptions. In short, we claim that when the language-production system is working well, *it looks to the future and does not dwell on the past*. (Dell et al. 1997:123, emphasis added)

The definition of the CC correspondence relation as an asymmetric, anticipatory mapping ($C_1 \leftarrow C_2$) is a direct reflection of the very properties of serial encoding in speech production described by Dell and colleagues. In the speech production domain, C_2 is already being activated at the point when C_1 is being executed. In the phonological domain, C_1 is a correspondent of C_2; this means that a "channel" exists by which the surface properties of C_1 can be directly influenced by those of C_2. On the assumption that consonant harmony represents, in some sense, the phonologized counterpart of on-line production errors, the correlation is not surprising. It should be emphasized, however, that consonant harmony effects are not the same thing as speech errors. The former are phonologized, systematic sound patterns, thoroughly entrenched in the grammatical system of the language in question, and have all the hallmarks of truly *phonological* phenomena. For example, the recursive character of sibilant harmony in Ineseño Chumash (e.g., /s-iʃ-tiʃi-jep-us/ 'they (2) show him' → [sistisijepus]) is a property which is not found in speech errors. The intricate interaction of many consonant harmony systems with morphological structure attests to its grammatical nature.

Recall that in those consonant harmony systems where morphological constituency defines directionality, perseveratory harmony (left-to-right, stem-to-suffix) is quite frequently observed. At first glance, this would appear to be incompatible with the definition in (21) of CC correspondence as a strictly anticipatory relation. As we shall see in subsequent sections, however, agreement over a strictly anticipatory correspondence relation can give rise to perseveratory/progressive assimilation as a by-product of constraint interaction.

To conclude, a given CORR-C↔C constraint establishes an anticipatory correspondence mapping from C_2 to C_1, provided that the $C_1 \ldots C_2$ pair in question falls above the thresholds of relative similarity and proximity (distance) specified in that constraint. The asymmetry of the relation accounts for the cross-linguistic generalization that, other things being equal, consonant harmony obeys anticipatory (regressive, right-to-left) directionality of assimilation. This asymmetry is a reflection of how sequentially ordered segments interact with one another in the process of phonological encoding for speech production. However, when other things are not equal—e.g. when morphological constituency overrides this default directionality—constraint interaction can give rise to perseveratory (left-to-right) assimilation.

4.2.2. The IDENT[F]-CC Constraint Family

As explained above, CORR-C↔C constraints merely establish a correspondence relation from C_2 to C_1, provided that the C_1/C_2 pair fulfills certain criteria of relative similarity and proximity. This correspondence is an abstract relation; it does not in and of itself place any specific demands on identity or agreement between C_1 and C_2. As such, CC correspondence merely establishes a kind of 'co-indexation' of C_1 and C_2. For the purpose of a particular CORR-C↔C constraint, the two representations [$k_x ik^h_x a$] and [$k^h_x ik^h_x a$] are equally good; in both cases, the C_1 corresponds to C_2 (as indicated by the subscript "x" indices) The fact that the correspondence is an *imperfect* one in the first case ([k]←[k^h] rather than [k^h]←[k^h]) is a separate issue, which is of no concern to the CORR-C↔C constraints. In fact, a third alternative, [$k^h_x ik^h_y a$], is worse than [$k_x ik^h_x a$] according to CORR-C↔C, despite the fact that C_1 and C_2 are identical in the former but not the latter ([k^h…k^h] vs. [k…k^h]). The reason is that in [$k^h_x ik^h_y a$], C_1 is not a correspondent of C_2.

Evaluating the 'goodness' of the C_1←C_2 correspondence mapping over a particular C_x…C_x sequence is the responsibility of IDENT[F]-CC constraints. Each IDENT[F]-CC constraint requires that if a given consonant in the output string is [αF], then any CC-correspondent of that consonant must also be [αF]. The definition in (22) is more or less identical to that given in Walker (2000a, 2000c, 2001) and Rose & Walker (2004); we will have reason to modify it later on.

(22) IDENT[F]-CC (to be revised!)

If an output consonant C_i is [αF], and C_j is any correspondent of C_i in the output, then C_j is [αF].

It is important to note that since CC correspondence is a strictly anticipatory (right-to-left) relation, as explained in the previous section, this in effect means that in a C_x…C_x sequence, if C_2 is [αF], then C_1 must also be [αF]. The effect of IDENT[F]-CC is shown schematically in (23), where the presence of a CC correspondence relation between the two consonants is presupposed. Note that we are dealing here with sequences of consonants that are potentially separated by a considerable stretch of intervening segmental material. Thus [C_1…C_2] might stand for the [s_x…$ʃ_x$] sequence in an output representation like [ʔəs_xɪmɪˈleɪ$ʃ_x$ən]. That particular sequence violates IDENT[anterior]-CC in the way shown in the second example in (23b), since [ʃ] is [–anterior] whereas its correspondent [s] is [+anterior].

(23) Effect of IDENT[F]-CC under asymmetric correspondence ($C_1 \leftarrow C_2$)

a. Output sequences which satisfy IDENT[F]-CC

C_1	…	C_2	C_1	…	C_2
[+F]		[+F]	[–F]		[–F]

b. Output sequences which violate IDENT[F]-CC

C_1	…	C_2	C_1	…	C_2
[–F]		[+F]	[+F]		[–F]

In (22)–(23), IDENT[F]-CC has been treated as a *featurally symmetric* (value-neutral) constraint, requiring that C_1 carry the same specification for [F] as C_2 does, regardless whether that value is [+F] or [–F]. Under these conditions, the inherent directional asymmetry of the correspondence relation is not immediately apparent. Both of the disharmonic sequences in (23b) violate IDENT[F]-CC to the same degree. The fact that it is C_1 which is required to agree with C_2, rather than the other way around, has no tangible effects. This changes if IDENT[F] constraints are relativized to specific feature values (McCarthy & Prince 1995, 1999, Pater 1999), as discussed earlier. In place of monolithic IDENT[F]-CC, we would then have separate IDENT[+F]-CC and IDENT[–F]-CC constraints as defined in (24).

(24) Value-specific IDENT[F]-CC constraints (to be revised!)

a. IDENT[+F]-CC
If an output consonant C_i is [+F], and C_j is any correspondent of C_i in the output, then C_j is [+F].

b. IDENT[–F]-CC
If an output consonant C_i is [–F], and C_j is any correspondent of C_i in the output, then C_j is [–F].

Under value-specific IDENT, the directional asymmetry inherent in the $C_1 \leftarrow C_2$ correspondence relation becomes evident. The schematic examples in (25) show the effect of the [+F] version of the constraint. The same applies, *mutatis mutandis*, to the [–F] version of the same constraint.

(25) Effect of IDENT[+F]-CC under asymmetric correspondence ($C_1 \leftarrow C_2$)

a. Output sequences that satisfy IDENT[+F]-CC

C_1	…	C_2	C_1	…	C_2	C_1	…	C_2
[+F]		[+F]	[–F]		[–F]	[+F]		[–F]
				(vacuous)			*(vacuous)*	

b. Output sequence that violates IDENT[+F]-CC

C_1 … C_2
[+F] [–F]

Unlike its value-neutral counterpart, IDENT[+F]-CC only penalizes one type of 'disharmonic' sequence: where a [+F] specification on C_2 is not matched by [+F] on the correspondent C_1. When C_2 is *not* [+F], IDENT[+F]-CC is vacuously satisfied.

There is reason to believe that value-specific IDENT constraints are needed in order to account for the full range of attested consonant harmony phenomena. In some cases, the harmony is *featurally asymmetric*, in that it involves the 'transmission' of only one feature value, not both; in what follows, these will be referred to as *single-value* systems. Nasal consonant harmony in Bantu languages is a case in point: a voiced oral consonant in a suffix is required to be [+nasal] when preceded by a [+nasal] consonant in the stem, but suffix nasals do not get denasalized under the influence of a voiced [–nasal] stem consonant. Thus /m…d/ → [m…n], but not /b…n/ ↛ [b…d].[28] Not surprisingly, Walker (2000c) crucially relies on value-specific IDENT[+nasal]-CC in her analysis of Yaka nasal consonant harmony (in Rose & Walker 2004 the relevant constraint is IDENT[nasal]-C_LC_R, with privative [nasal] rather than [+nasal]; see n. 27 above) Other examples involve obstruent voicing harmony, where the "spreading" feature is [+voice] (to the exclusion of [–voice]), or sibilant harmony systems where alveolars ([+anterior]) assimilate to postalveolars ([–anterior]) but not vice versa.[29]

In the literature on vowel harmony systems, featurally asymmetric (single-value) harmony is traditionally called *dominant-recessive*. In such systems, vowels carrying the active [F]-value are "dominant" in the sense that they impose their specification for [F] onto other vowels in the harmony domain, whereas vowels with the inactive value are called "recessive". Single-value consonant harmony could be called "dominant-recessive" as well, but there are reasons to avoid this terminology here. First of all, drawing seemingly-intuitive parallels between vowel harmony and consonant harmony may do more harm than good. As has

[28] An interesting exception is Tiene, where nasals *do* denasalize in order to harmonize with (non-nasalizable) [s], as discussed in §2.4.4 above (Hyman & Inkelas 1997; see also §4.3.3 below). Note that the issue of featurally asymmetric vs. featurally symmetric harmony is orthogonal to that of directionality. Thus, the fact that /b…n/ does not surface as [m…n], "spreading" [+nasal] just as in the attested cases, follows from the generalization that the harmony obeys *inside-out* directionality, with suffixes harmonizing to the preceding stem rather than the other way around. There do exist cases where nasal consonant harmony instead obeys strict *anticipatory* (right-to-left) directionality, regardless of morphology. In Pangwa, reciprocal /-an-/ triggers nasalization on a preceding (stem-final) velar: [-pulix-] 'listen to' vs. [-puliŋ-an-] 'listen to each other' (Stirnimann 1983). See §4.3.3 for discussion.

[29] See chapter 6 for discussion of such "palatal bias" effects in coronal harmony systems as well as in phonological speech errors.

been argued throughout this work, the a priori assumption that consonant harmony is homologous with vowel harmony (e.g., that both must involve feature/gesture spreading) has impeded our understanding of the true nature of consonant harmony as a phenomenon.

Secondly, a great many dominant-recessive vowel harmony systems involve *bidirectional* assimilation. Thus, in a language where [+ATR] vowels are dominant, it is often the case that both [+ATR]…[–ATR] and [–ATR]…[+ATR] sequences are harmonized to [+ATR]…[+ATR]. In fact, Baković (2000) has made the strong claim that *unidirectional* dominant-recessive harmony is entirely unattested. Though it is doubtful that this claim will stand up to scrutiny as a generalization about vowel harmony systems, it is abundantly clear that it does not carry over to consonant harmony. For example, there are single-value sibilant harmony systems (where the active value is [–anterior]) which clearly obey strict anticipatory directionality, without any regard to morphological structure. In Nkore-Kiga sibilant harmony, for example, the agreement between sibilants that are separated by more than one syllable displays "dominance" in this sense: [s] assimilates to [ʃ], but [ʃ] does not assimilate to [s]. At the same time, the harmony is strictly right-to-left (potentially from suffix to stem), such that /…sVCVʃ…/→ […ʃVCVʃ…] but the mirror-image /…ʃVCVs…/ does not harmonize to […ʃVCVʃ…].[30] In short, single-value consonant harmony *can* indeed be unidirectional. In fact, truly bidirectional single-value systems—ones that would be direct analogues to the prototypical dominant-recessive vowel harmony system—appear entirely unattested.[31] This is not too surprising, given the fact that even dominant-recessive vowel harmony systems are quite rare, and may be confined to [±ATR] harmony.

Finally, Baković (2000) claims that in dominant-recessive vowel harmony systems, the dominant vowels are always less marked than their recessive counterparts (a pattern he refers to as "assimilation to the unmarked"). This is most certainly untrue of single-value consonant harmony systems as a class. As will be discussed in greater detail in chapter 6, single-value sibilant harmony always involves the postalveolar ('palatal') series as the active one, such that [ts], [s], [z], etc. yield to [tʃ], [ʃ], [ʒ], etc. rather than vice versa. Likewise, in obstruent voicing harmony the active value is generally [+voice], even though [–voice] is arguably the unmarked state for obstruents. If anything, the typology of consonant harmony points toward assimilation to the *marked* being the prevalent pattern in single-value systems. Incidentally, similar asymmetries have been observed in speech error studies. For example, Stemberger (1991) finds that in contextual speech errors (anticipations or perseverations), postalveolar

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[30] At shorter distances, the sibilant harmony is featurally symmetric, double-value harmony rather than single-value, "transmitting" [–anterior] and [+anterior] alike. The anticipatory directionality still holds in these cases: we see sVʃ → ʃVʃ, but ʃVs → sVs.

[31] In such a system, the active value [αF] would 'spread' from *any* morpheme (prefix, stem or affix) to any (relevant) [–αF] consonant in preceding and following morphemes. Kera obstruent voicing harmony does not qualify as an instance of this, even though it "spreads" [+voice] bidirectionally, because the directionality is strictly *inside-out* (or "cyclic"), with affixes assimilating to the stem to which they attach (cf. §3.2 above).

sibilants tend to intrude on alveolar sibilants (see chapter 6), voiced obstruents tend to intrude on voiceless ones, nasals and fricatives tend to intrude on stops, labials tend to intrude on alveolars, and so forth.[32] Such parallels between speech errors and consonant harmony processes are only to be expected if the latter are rooted in the domain of speech planning, as argued here.

To conclude, there are cases where the analysis of consonant harmony seems to require value-specific IDENT constraints, notably single-value systems. These are analogous to dominant-recessive vowel harmony systems, in that only one [F]-value is active (triggering assimilation), but there is reason to be wary of making too much of this analogy. Baković (2000) explicitly rejects the use of value-specific IDENT-IO constraints to account for dominant-recessive vowel harmony, on the grounds that it fails to capture his generalization about "assimilation to the unmarked". However, as explained above, consonant harmony *does not* obey this generalization, and it is therefore irrelevant as an argument against value-specific IDENT. In the next section, the basic machinery of the ABC analysis is illustrated with a simple single-value system. The analysis utilizes both value-specific IDENT-CC constraints and the right-to-left asymmetry built into the CC correspondence relation. It also introduces the idea that the harmony-enforcing IDENT-CC constraints are to be construed as *targeted* constraints (in the sense of Wilson 2000, 2001, 2003, 2006; see also Baković & Wilson 2000), a notion which becomes crucial in §4.3.1 below.

4.2.3. Fundamental Ranking Requirements

In this section, we will see how the constraints introduced in §4.2.1 and §4.2.2 interact to give rise to harmony patterns. This will be illustrated with a simple case; subsequent sections will introduce progressively more complex phenomena that call for more intricate constraint interactions. The particular example analyzed here is the obstruent voicing harmony found in the West Chadic language Ngizim (Schuh 1978, 1997). The basic facts were described in §2.4.7 above, but are recapitulated here. Ngizim voicing harmony is a morpheme-internal co-occurrence restriction. Since it does not reach beyond the confines of the root, the harmony does not manifest itself in the form of alternations, but merely as a static constraint on (non-adjacent) obstruent sequences within roots. Examples of roots containing obstruents that agree in voicing are given in (26). Note that the effect of the harmony as a diachronic process in Ngizim can clearly be seen by considering cognates in related languages, as shown in (26b).

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[32] Stemberger (1991) explicitly argues that his findings reflect representational differences due to (radical) underspecification, not markedness differentials as such. In the present context, however, that distinction is irrelevant; the important point is simply that the consonant harmony phenomena are *not* consistent with "assimilation to the unmarked", and neither are the speech error generalizations discussed by Stemberger.

(26) Ngizim voicing harmony (data from Schuh 1997 unless otherwise noted)

a.	kùtə́r	'tail'	
	ɬəpú	'clap' (Schuh 1978:260)	
	tàsáu	'find'	
	sətú	'sharpen to point' (Schuh 1978:260)	
b.	gâːzá	'chicken'	(< **k*...*z*; cf. Hausa /kàːzáː/)
	də́bâ	'woven tray'	(< **t*...*b*; cf. Hausa /tàːfíː/ 'palm')
	zàbìjú	'clear field'	(< **s*...*b*; cf. Hausa /sásːàbéː/)
	zədù	'six'	(< **s*...*d*; cf. Hausa /ʃídà/)

As is evident from the Hausa cognates in (26b), Ngizim voicing harmony is a matter of anticipatory assimilation, involving the feature value [+voice]. A voiceless obstruent is harmonized to [+voice] when a [+voice] obstruent follows within the same morpheme. The asymmetry inherent in this process is also evident synchronically within the Ngizim lexicon. Although voiceless-voiced sequences are disallowed (or at least severely underrepresented; some later borrowings appear to be exceptions), voiced-voiceless ones abound, as shown in (27).

(27) Asymmetric character of Ngizim voicing harmony (D…T, but no *T…D)

bàkú	'roast'	(Schuh 1997)
zàpənú	'churn'	(Schuh 1978:254)
gùmtʃí	'chin'	(Schuh 1997)
dùkʃí	'heavy'	(Schuh 1978:251)
zùktú	'pierce'	(Schuh 1978:273)
mbàsú	'sit'	(Schuh 1978:262)

Ngizim harmony is thus a strictly anticipatory effect: a *preceding* [+voice] obstruent will not induce voicing harmony (thus /bàkú/ 'roast' does not harmonize to *[bàgú]). Furthermore, the restriction is a matter of single-value harmony, [+voice] being the "active" value. An obstruent which is [–voice] does not trigger anticipatory devoicing (that is, /bàkú/ does not harmonize to *[pàkú]). An adequate analysis of Ngizim harmony must account for each of these asymmetries.

As explained in §4.2.1.2 above, the correspondence relation established by CORR-C↔C constraints is inherently anticipatory ($C_1 \leftarrow C_2$). Furthermore, CORR-C↔C constraints form a hierarchy based on the relative similarity of C_1 and C_2. The greater the similarity, the stronger the demand for $C_1 \leftarrow C_2$ correspondence. To some extent, the effect of relative similarity on the ranking of CORR-C↔C constraints is inherently predictable. A constraint demanding correspondence between consonants differing at most in the feature set [F, G] dominates one demanding correspondence between consonants differing at most in [F, G, H]. But what about constraints which are not in a subset relation, ones that invoke [F, G] vs. [F, H], say? Here the question of relative similarity is not as simple. As was argued in §4.2.1.1, there is reason to believe that languages may define different similarity relations in such cases; that is, they may differ in the relative ranking of the CORR-C↔C constraints in question.

For the purposes of Ngizim voicing harmony, the set of consonants that are singled out by high-ranked CORR-C↔C constraints includes all obstruents (stops, fricatives, affricates) regardless of any differences in place of articulation and/or stricture features. Sonorants, by contrast, do not trigger voicing harmony (/kùtə́r/ 'tail' does not become *[gùdə́r], and /zàpə̀nú/ 'churn' does not become *[zàbə̀nú]). Two consonants differing in [±voice] and [±sonorant] (e.g., [t…n]) are thus treated by the phonology of Ngizim as being *less* similar than ones differing in [±voice], [Place] and [±continuant] (e.g. [s…b]).[33] The similarity scale relevant for Ngizim, encoded in terms of differentially-ranked CORR-C↔C constraints, is shown in (28).

(28) Relevant portion of CORR-C↔C hierarchy for Ngizim

CORR-[voi] >> CORR-[voi, Place] >> CORR-[voi, Place, cont] >> CORR-[voi, son]

As before, the bracketed features denote the properties in which the two consonants in question may maximally differ; see (21) above. Thus CORR-[voice] demands correspondence between a pair of output consonants differing *at most* in [±voice] (e.g., [g…k], [s…z], as well as [k…k], [z…z], etc.). CORR-[voice, Place] demands correspondence between consonants differing at most in [±voice] and [Place] simultaneously; this includes all the pairs covered by higher-ranked CORR-[voi], and also heterorganic pairs like [g…t] or [f…z]. The fact that CORR-[voice, Place, continuant] outranks CORR-[voice, sonorant] reflects the language-specific fact that the demand for $C_1 \leftarrow C_2$ correspondence between two obstruents is greater than that between an obstruent and a sonorant, even if the former differ in place, voicing and stricture, and the latter only in voicing.

The top three of the CORR-C↔C constraints listed in (28) have the effect of establishing a correspondence relation in obstruent…obstruent sequences. Note that this alone does not induce voicing harmony, nor any other kind of overt interaction between obstruents. The constraint responsible for enforcing voicing agreement is IDENT[+voice]-CC. When an output representation contains a sequence [$C_1 \ldots C_2$], where C_1 and C_2 are both obstruents and C_1 is thus a correspondent of C_2 ($C_1 \leftarrow C_2$), IDENT[+voice]-CC requires that if C_2 is [+voice], then its correspondent C_1 must likewise be [+voice].

In order for voicing harmony to be enforced, faithfulness to input [±voice] specifications must be outranked by IDENT[+voice]-CC, as well as by the relevant CORR-C↔C constraints (again, the top three from (28)). The combined effect of these constraints is illustrated in (29) using the example [gâːzá] 'chicken' (from historically earlier [k…z], cf. Hausa [kàːzáː]). Note

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[33] Of course, [t] and [n] also differ in [±nasal], but note that the [+nasal] specification on [n] is redundant, in the sense that it is predictable from [+sonorant, –continuant]. Besides, the pair [s…b] differs in [±strident] as well (likewise a redundant feature).

that the *actual* input representation of this particular word in the Ngizim lexicon would of course be /gâːzá/ (by Lexicon Optimization; Prince & Smolensky 2004). Nevertheless, the derivation in the tableau shows us how obstruent voicing harmony would be enforced even with a hypothetical disharmonic input /kâːzá/.

As in the tableaux in §4.1.3 above (and following Rose & Walker 2004), IO correspondence relations are indicated with subscript digits ("1", "2") and CC correspondence with subscript letters ("x", "y"). Thus in candidate (29b) the output segment [$k_{1,x}$] corresponds to the input segment /k_1/ (by IO correspondence) and also to the following output segment [$z_{2,x}$] (by CC correspondence). Its faithfulness to /k_1/ is evaluated by IDENT-IO constraints, including IDENT[–voice]-IO. Its "faithfulness" (or, rather, agreement) to [$z_{2,x}$] is assessed by IDENT-CC constraints, in particular IDENT[+voice]-CC. In candidate (29a), by contrast, the output segment [$k_{1,x}$] corresponds only to input /k_1/. It does not correspond to the following output segment [$z_{2,y}$], as the subscript indices show (x ≠ y). In that case, IDENT[+voice]-CC is vacuously satisfied, since there is no CC correspondent pair present for the constraint to evaluate.

(29) Ngizim obstruent voicing harmony (heterorganic stop vs. fricative):

/k_1âːz_2á/	ID[+voi]-CC	CORR-[voi, Pl]	CORR-[voi, Pl, cont]	ID[–voi]-IO	CORR-[voi, son]
a. $k_{1,x}$âː$z_{2,y}$á			*!		
b. $k_{1,x}$âː$z_{2,x}$á	*!				
c. ☞ $g_{1,x}$âː$z_{2,x}$á				*	
d. $g_{1,x}$âː$z_{2,y}$á			*!	*	

With respect to the similarity-based hierarchy of CORR-C↔C constraints, the tableau in (29) displays only the relevant portion CORR-[voice, Place] >> CORR-[voice, Place, continuant] >> CORR-[voice, sonorant]. Top-ranked CORR-[voice] is omitted to reduce clutter in the tableau. In this particular example, the input C_1 and C_2 differ in three features: [±voice], [Place] and [±continuant]; the highest-ranked CORR-C↔C constraint covering such a pair is CORR-[voice, Place, continuant]. The tableau in (30) shows a case where higher-ranked CORR-[voice, Place] is relevant as well. Here the two input consonants differ only in [±voice] and [Place], not in [±continuant]. The example derives the correct output for [dә́bâ] 'woven tray', even in the face of a (hypothetically) disharmonic input /tә́bâ/.

(30) Ngizim obstruent voicing harmony (heterorganic stops):

/t$_1$ə́b$_2$â/	ID[+voi]-CC	CORR-[voi, Pl]	CORR-[voi, Pl, cont]	ID[−voi]-IO	CORR-[voi, son]
a. t$_{1,x}$ə́b$_{2,y}$â		*!	*		
b. t$_{1,x}$ə́b$_{2,x}$â	*!				
c. ☞ d$_{1,x}$ə́b$_{2,x}$â				*	
d. d$_{1,x}$ə́b$_{2,y}$â		*!	*	*	

Finally, the analysis accounts for the fact that sonorants fail to trigger voicing harmony. As shown in (31), /tərá/ 'moon' surfaces intact, not harmonized to *[dərá]. The highest-ranked CORR-C↔C constraint encompassing an obstruent-sonorant pair like this is CORR-[voice, sonorant]. Since this is ranked lower than IO faithfulness to input [±voice] specifications, the best option is to forego the CC correspondence relation between [t] and [r], as in (31a). With no correspondent pair to evaluate, the constraint IDENT[+voice]-CC is vacuously satisfied.

(31) Ngizim obstruent voicing harmony (sonorants are not triggers):

/t$_1$ər$_2$á/	ID[+voi]-CC	CORR-[voi, Pl]	CORR-[voi, Pl, cont]	ID[−voi]-IO	CORR-[voi, son]
a. ☞ t$_{1,x}$ə̀r$_{2,y}$á					*
b. t$_{1,x}$ə̀r$_{2,x}$á	*!				
c. d$_{1,x}$ə̀r$_{2,x}$á				*!	
d. d$_{1,x}$ə̀r$_{2,y}$á				*!	*

Another aspect of Ngizim voicing harmony, which was mentioned in §2.4.7 above, is that voiced *implosives* do not trigger harmony either, as is evident from the examples in (32). Even though they are unquestionably obstruents, implosives are just as inert for the purposes of voicing harmony as sonorants are:

(32) Ngizim: voiced implosives are non-triggers (data from Schuh 1997)

pə́ɗə́k	'morning'	(not *bə́ɗə́k)
kìiɗú	'to eat (meat)'	(not *gìiɗú)
fə́ɗú	'four'	(not *və́ɗú)
sàpɗú	'to pound'	(not *zàpɗú or *zàbɗú)

Assuming that the voiced pulmonic stop vs. voiced implosive stop distinction is a matter of [±constricted glottis] (henceforth [±c.g.]), the CORR-C↔C constraint covering sequences like /t…ɗ/, /ɓ…p/, etc. is CORR-[voice, c.g.]. The inertness of implosives in Ngizim voicing harmony—even in cases where the two stops are homorganic (i.e. maximally similar in other respects)—can thus be accounted for by positing the ranking CORR-[voice, Place, continuant] >> CORR-[voice, constricted glottis] for Ngizim. In other words, the grammar of Ngizim counts a segment pair like [t] vs. [ɗ] as being *less* similar than ones like [z] vs. [k], or [f] vs. [d]. By ranking the constraint CORR-[voice, c.g.] lower than IO faithfulness to [±voice], we achieve the right prediction, as shown in (33). The particular input-output pair in (33) is a contrived one, intended to illustrate the fact that voicing harmony fails for stops differing in [±constr. gl.] even if they are homorganic.

(33) Ngizim obstruent voicing harmony (implosives are not triggers):

/t_1a$ɗ_2$a/	ID[+voi]-CC	CORR-[voi, Pl]	CORR-[voi, Pl, cont]	ID[–voi]-IO	CORR-[voi, cg]
a. ☞ $t_{1,x}$a$ɗ_{2,y}$a					*
b. $t_{1,x}$a$ɗ_{2,x}$a	*!				
c. $d_{1,x}$a$ɗ_{2,x}$a				*!	
d. $d_{1,x}$a$ɗ_{2,y}$a				*!	*

Most likely the inertness of sonorants and implosives in Ngizim voicing harmony is connected to the fact that voicing is *redundant* in these segments. Whereas pulmonic obstruents contrast in [±voice] (/p/ vs. /b/, /f/ vs. /v/, /t/ vs. /d/, /s/ vs. /z/, etc.), sonorants and implosives do not, and [+voice] in these segments is thus predictable from their other feature specifications. I will return to the issue of contrastiveness and its relevance for consonant harmony in §5.3 of the next chapter.

All the previous tableaux have completely ignored the issue of anticipatory directionality and the designation of [+voice] as the active feature value. In order to be complete, the analysis must account for the fact that /tə́bâ/ does not harmonize to *[tə́pâ] (instead of correct [də́bâ]), and that /bàkú/ does not harmonize at all, neither to *[pàkú] (by anticipatory [–voice] harmony) nor to *[bàgú] (by perseveratory [+voice] harmony). Let us start with the second case, the fact that D…T sequences are not subject to harmony at all. This is shown in (34). To reduce clutter, all the CORR-C⇔C constraints have been omitted from the tableau; the candidate set has been reduced by simply taking for granted the presence of a $C_1 \leftarrow C_2$ correspondence relation between the two output consonants (ensured here by CORR-[voice, Place] >> IDENT[–voi]-IO). Note also that IDENT[+voi]-IO and IDENT[–voi]-CC have been added for completeness; the latter is ranked too low to have any effect.

(34) Ngizim: no voicing harmony in [+voice]…[–voice] sequences

/b_1àk_2ú/	ID[+voi]-CC	ID[+voi]-IO	ID[–voi]-IO	ID[–voi]-CC
a. ☞ $b_{1,x}$à$k_{2,x}$ú				*
b. $p_{1,x}$à$k_{2,x}$ú		*!		
c. $b_{1,x}$à$g_{2,x}$ú			*!	
d. $p_{1,x}$à$g_{2,x}$ú	*!		**	

It is important to note that the faithful winning candidate (34a) does *not* violate the top-ranked IDENT[+voice]-CC constraint, even though it is "disharmonic" with respect to voicing. Recall that the CC correspondence relation is inherently directional, $C_1 \leftarrow C_2$. The constraint thus requires that a [+voice] specification on C_2 must be reflected in its correspondent C_1. In (34a), C_2 is not [+voice], and the constraint IDENT[+voice]-CC is thus vacuously satisfied. The fact that C_1 is [+voice] but not C_2 is of no relevance to IDENT[+voice]-CC. Since C_2 is *not* a correspondent of C_1 (only the other way around) IDENT[+voi]-CC in no way requires that the [+voice] specification on C_1 be copied onto C_2. Note that low-ranked IDENT[–voice]-CC does penalize (34a) and favor the options of either transmitting the [–voice] value of C_2 onto C_1 (34b), or to make C_1 match C_2 by having the latter be [+voice] (34c). But the constraint IDENT[–voice]-CC is outranked by faithfulness to input [±voice] specifications and thus has no effect; this explains why D…T sequences are not harmonized, neither to D…D nor to T…T. In general, the ranking schema IDENT[αF]-CC >> FAITH-IO >> IDENT[–αF]-CC gives rise to a single-value harmony system, with [αF] being the active or "dominant" value and [–αF] the inactive ("recessive") one.

The example derivation in (34) showed how, in the case of an input sequence /D…T/, complete faithfulness is better than either perseveratory [+voice] harmony (D…D) or anticipatory [–voice] harmony (T…T). Earlier, in (29)-(30), we saw how in /T…D/ cases, anticipatory [+voice] harmony can win out over faithfulness, /tə́bâ/ surfacing as [də́bâ] 'woven tray' rather than *[tə́bâ]. But what about the option of perseveratory [–voice] harmony: *[tə́pá]? Here we run into an unexpected problem. The CC correspondence relation was defined as strictly anticipatory, $C_1 \leftarrow C_2$, precisely in order to account for the absolute right-to-left directionality found in many consonant harmony systems, including Ngizim. Furthermore, IDENT[voice]-CC was split into (higher-ranked) IDENT[+voice]-CC and (lower-ranked) IDENT[–voice]-CC to account for the fact that only [+voice] is active in Ngizim. Given that these measures have been taken, one might expect that the analysis would at the very least correctly derive the 'spreading' of [+voice] from C_2 to C_1, harmonizing [–voice]…[+voice] sequences to [+voice]…[+voice]. However, things are not so simple, as (35) shows.

(35) Ngizim: indeterminacy in deriving voicing harmony (to be revised!)

/t₁ə́b₂â/	ID[+voi]-CC	ID[+voi]-IO	ID[–voi]-IO	ID[–voi]-CC
a. $t_{1,x}$ə́$b_{2,x}$â	*!			
b. ☞ $d_{1,x}$ə́$b_{2,x}$â			*	
c. ☞ $t_{1,x}$ə́$p_{2,x}$â		*		

While it does correctly rule out the (faithfully) disharmonic candidate (35a), the constraint IDENT[+voice]-CC is unable as such to choose which harmonic option is better, anticipatory [+voice] harmony (35b)—our intended winner—or perseveratory [–voice] harmony (35c). The choice will therefore be left to other, lower-ranked constraints that have nothing to do with voicing harmony. For example, the relative ranking of the constraints IDENT[–voice]-IO and IDENT[+voice]-IO might decide the matter; if they are crucially ranked in the order in which they are displayed in (35), the correct output (35b) will indeed be optimal. (Of course, if one rejects value-specific IDENT[F]-IO constraints, this is not an option.)

At some level, the tie in (35)—that is, the fact that (35b) and (35c) tie on the constraint that is intended to drive *anticipatory* harmony—should come as a bit of a surprise. Recall that IDENT[+voi]-CC, by definition, requires a [+voice] C_2 to induce [+voice] on C_1, given that the CC correspondence relation has been explicitly construed as a directional, anticipatory relation. The source of the problem is the fact that IDENT[+voi]-CC is ultimately a well-formedness constraint on *output* representations: technically, it thus constitutes a Markedness constraint, despite its formalization as a correspondence constraint. As such, all this constraint can do is to penalize a particular output configuration, namely a [–voice]…[+voice] sequence of consonants linked by $C_1 \leftarrow C_2$ correspondence, as in the faithful candidate (35a). In other words, the constraint merely bans disharmony of a certain kind; it does not specify a 'repair strategy'. For this reason, IDENT[+voi]-CC cannot itself distinguish between the two 'non-disharmonic' candidates (35b) and (35c).

If Input-Output faithfulness to featural specifications (IDENT[F]-IO) is regulated by value-specific versions, with IDENT[+voice]-IO and IDENT[–voice]-IO as distinct constraints, as shown above, then this provides an easy 'fix' to the indeterminacy problem. In (35), the relative ranking of the two IO faithfulness constraints will determine which is optimal, (35b) or (35c). By assuming the ranking in (36), then, we could ensure that a disharmonic structure—that is, a [–voice]…[+voice] sequence of corresponding consonants—will always be repaired by means of *anticipatory* voicing harmony rather than perseveratory 'voicelessness harmony'.[34]

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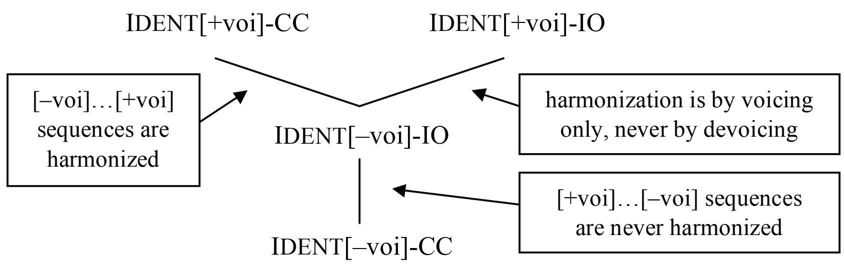
[34] This is exactly how Walker (2000c) and Rose & Walker (2004) handle the fact that Yaka nasal consonant harmony involves perseveratory nasalization (/m…d/ → [m…n]) but never anticipatory denasalization (/b…n/ ↛ [b…d]). This is captured by positing IDENT-IO(nas) >> IDENT-OI(nas), which is equivalent to IDENT[+nas]-IO >> IDENT[–nas]-IO.

(36) An attempt at deriving anticipatory voicing harmony (provisional):



The solution in (36) is unfortunate in several respects. Firstly, the preference of (35b) over (35c) is stipulated, by declaring that, other things being equal, Ngizim prefers the change of [–voice] → [+voice] over the reverse change [+voice] → [–voice]. Secondly, reliance on IO faithfulness constraints to regulate directionality (albeit indirectly) is a strategy that will not work for cases in which the [F] value carried by the (intended) trigger consonant is not necessarily a faithful one, but one which is imposed by some other phonological process, or is determined by allophonic distribution; we will encounter such cases in chapter 5. Most importantly, however, the preference of (35b) over (35c) has nothing to do with the CC correspondence relation or the IDENT[F]-CC constraints that evaluate it. If our original intention was to derive directionality effects by means of a directional correspondence relation, the conclusion to draw from (36) is that we have failed. It would have been just as easy to stipulate the opposite ranking of IO faithfulness constraints, IDENT[–voi]-IO >> IDENT[+voi]-IO, with the result that the obstruent voicing agreement would manifest itself as *perseveratory (left-to-right) voicelessness* harmony. This despite our explicit definition of CC correspondence as an *anticipatory* (right-to-left) relation ($C_1 \leftarrow C_2$), and the high ranking of IDENT[+voi]-CC, a constraint that is intended to encode the need to ‘spread’ voicing from C_2 to C_1, not voicelessness from C_1 to C_2.

There is a sense in which an important generalization is being missed here, one that was hinted at earlier. Recall that IDENT[+voi]-CC is defined as a conditional proposition: *if* $C_1 \leftarrow C_2$ and C_2 is [+voice], *then* C_1 is [+voice]. Neither [də́bâ] (35b) nor [tə́pâ] (35c) violate this constraint, but they satisfy it for very different reasons. Candidate (35b) can be said to truly satisfy the constraint, in the sense that the antecedent (‘if …’) holds true and the consequent (‘then …’) also holds true. The ‘reverse-harmonized’ candidate (35c), by contrast, satisfies the constraint *vacuously*: the antecedent is not met (C_2 is not [+voice]), rendering the consequent irrelevant. From this perspective, [tə́pâ] ‘passes’ on IDENT[+voice]-CC in much the same way as innumerable other bizarre options would, such as [tə́mâ], [ə́bâ], and so forth. In short, there is a much more direct relationship between the disharmonic candidate (35a) and the harmonic candidate (35b) than there is between (35a) and (35c). The former two, (35a) and (35b), both satisfy the description in the antecedent part of IDENT[+voice]-CC (‘if $C_1 \leftarrow C_2$ and C_2 is [+voi]’); they differ in that (35a) violates the consequent (‘… then C_1 is [+voi]’) whereas (35b) satisfies it.

We could thus say that (35b) is the 'harmonized counterpart' to (35a). The fully faithful candidate (35a) would be the favored output were it not for high-ranked IDENT[+voi]-CC. Candidate (35b), in a sense, represents a minimal adjustment from (35a) in order to satisfy the consequent portion of this constraint. Can this close relationship between such candidate pairs be formalized within an OT analysis? The answer is yes; this, essentially, is the core of the theory of *targeted constraints* as proposed by Wilson (2000; see also Wilson 2001, 2003, 2006, Baković 2000, Baković & Wilson 2000, Hansson 2001b, 2006b, McCarthy 2002b). A targeted constraint differs from ordinary well-formedness (i.e. Markedness) constraints in that it targets a specific portion of the output representation—some particular marked element or structure—and forces it to move out of its marked state *while the surrounding elements remain constant*. A targeted constraint is an 'other-things-being-equal' version of usual well-formedness constraints: given two candidates that are otherwise identical, the one with the targeted (marked) element is dispreferred.

For example, in their analysis of Wolof tongue-root vowel harmony, Baković & Wilson (2000) propose that the constraint requiring high vowels to be consistently [+ATR] is in fact a targeted constraint, →NO(+HI,–ATR). (The superscript arrow '→' serves as a useful diacritic to identify a constraint as targeted.) This constraint targets [+high, –ATR] vowels, forcing them to change (minimally) into a less marked state. The effect of →NO(+HI,–ATR) can be summarized as follows: given two output candidates *x* and *x′*, candidate *x′* is preferred over *x* ($x' \succ x$) if and only if *x′* is exactly like *x* except that at least one [+high, –ATR] vowel in *x* has been replaced in *x′* by a vowel that is not [+high, –ATR].[35] Given two candidates [tɛɛr-ʊw-ɔɔn] and [tɛɛr-uw-ɔɔn], →NO(+HI,-ATR) prefers the latter over the former: in the latter, the marked vowel [ʊ] of the former has been replaced with [u], but the two strings are otherwise completely identical. In other words, transparency (with the vowels on either side agreeing in [–ATR]) is preferred over full harmony. A third alternative, [tɛɛr-uw-oon], in which the medial [u] is behaving as an opaque rather than a transparent intervener, is not preferred over fully-harmonized [tɛɛr-ʊw-ɔɔn]. The reason is that [tɛɛr-uw-oon] is *not* 'exactly like' [tɛɛr-ʊw-ɔɔn] except for the marked vowel [ʊ]. Thus, this pair of representations does not fit the description of *x* and *x′* that is implicit in the definition of →NO(+HI,-ATR), and that constraint therefore has nothing to say about the relative well-formedness of this particular pair of candidate outputs.

The proposal that will be advocated in this work is that the constraints ultimately responsible for consonant harmony—IDENT[F]-CC constraints—are to be construed as *targeted* constraints. The full implications of this move will be discussed in greater detail in §4.3.1

[35] This characterization omits an important aspect of the definition of the targeted constraint →NO(+HI,–ATR), namely that the vowel in *x′* that 'replaces' the targeted [+high, –ATR] vowel of *x* must be minimally distinct from it (according to a particular similarity metric). The constraint does not prefer *x′* over *x* if it replaces, say, [ɪ] with [æ] (rather than with [i]). Although grounding in terms of perceptual and articulatory considerations is an integral part of Wilson's notion of targeted constraints, it will not be directly relevant here.

below. Here it will suffice to sketch how this alternative interpretation affects the indeterminacy issue in (35) above. The relevant tableau is repeated in (37). The low-ranked constraint IDENT[–voi]-CC has been omitted, since it is irrelevant in this context. Also, in order to emphasize the point made above about the unsuitability of differentially-ranked IDENT[+F]-IO vs. IDENT[–F]-IO constraints as the crucial deciding factor, IO faithfulness will here be represented through monolithic IDENT[±F]-IO constraints. (The reader should feel free to think of these as 'cover constraints' for {IDENT[+F]-IO, IDENT[–F]-IO} pairs.)

(37) Ngizim: indeterminacy issue revisited (repeated from (35))

/t_1ə́b_2â/	IDENT[+voi]-CC	IDENT[±voi]-IO
a. $t_{1,x}$ə́$b_{2,x}$â	*!	
b. ☞ $d_{1,x}$ə́$b_{2,x}$â		*
c. ☞ $t_{1,x}$ə́$p_{2,x}$â		*

To understand how construing IDENT[+voi]-CC as a targeted constraint can resolve the dilemma in (37), we must first define the constraint as such. A tentative definition of the targeted constraint →IDENT[+voice]-CC is given in (38):

(38) →IDENT[+voice]-CC

Let x and x' be two candidate output representations, each of which contains two consonants C_i and C_j where $C_i \leftarrow C_j$ (C_i is a correspondent of C_j) and C_j is [+voice]. Candidate x' is preferred over x ($x' \succ x$) iff x' is exactly like x except that in x', the correspondent C_i is [+voice] rather than [–voice].

Recall that CC correspondence is strictly anticipatory (right-to-left; $C_1 \leftarrow C_2$), and thus C_i=C_1 and C_j=C_2. It is extremely important to note that a targeted constraint compares *pairs* of candidates and assesses their relative well-formedness; it does not evaluate individual candidates in isolation. The three candidates in (37) can be paired off with each other in three ways: (37a) vs. (37b), (37a) vs. (37c), and (37b) vs. (37c). We must then ask what, if anything, the constraint →IDENT[+voi]-CC has to say about *each* of these pairwise comparisons. First of all, the constraint clearly prefers (37b) over (37b); that is, (37b) ≻ (37a). Each contains two corresponding output consonants $C_1 \leftarrow C_2$ where C_2 is [+voice], and (37b) is exactly like (37b) except that in (37b), C_1 is [+voice] rather than [–voice].

But what about the other two candidate pairs? Closer inspection reveals that neither of them can qualify as x vs. x', because (37c) simply does not fit the description stated in the premise built into the constraint (its 'antecedent'). Candidate (37c) does contain two corresponding output consonants, $C_1 \leftarrow C_2$, but C_2 is not [+voice]. Therefore →IDENT[+voi]-CC has nothing whatsoever to say about the relative goodness of (37c) in relation to any other candidate, (37a) or (37b). This is analogous to the Wolof situation mentioned above. From the point of view of the targeted constraint →NO(+HI,–ATR), the opaque-[u] candidate [tɛɛr-uw-oon] is simply not comparable to the transparent-[u] candidate [tɛɛr-uw-ɔɔn], nor to the full-harmony candidate [tɛɛr-ʊw-ɔɔn]. In these comparisons, ‘other things’ are *not* ‘equal’; that is, the other properties of the candidates besides the crucial [ʊ]/[u] distinction. In our example in (37), →IDENT[+voi]-CC is unable to compare (37c) to either (37a) or (37b).

What would (37) look if we substituted targeted →IDENT[+voi]-CC for its non-targeted counterpart? In order to represent the interaction of a targeted constraint with other constraints, it is crucial to understand the fact that targeted constraints impose a *partial* ordering of the candidate set supplied by GEN. In Optimality Theory, each constraint can be said to impose a harmonic ordering on the representations that make up the candidate set. A constraint $\mathbb{C}$ thus prefers candidate x' over candidate x ($x' \succ x$) if x violates $\mathbb{C}$ but x' does not (or x violates $\mathbb{C}$ more severely than x' does). With non-targeted constraints, this harmonic ordering is *complete* in the sense that it exhausts the candidate set: *every* candidate that satisfies $\mathbb{C}$ is preferred over *every* candidate that violates $\mathbb{C}$ once, which is in turn preferred over *every* candidate that violates $\mathbb{C}$ twice, and so forth. This is not the case with targeted constraints, which merely pick out individual pairs of candidates and impose a harmonic ordering solely on the members of each of these pairs.

From this perspective on the evaluation of individual constraints, the way in which the EVAL function singles out the optimal output candidate can be characterized as follows. The harmonic orderings over the candidate set that are imposed by individual constraints are added up in a cumulative fashion, with higher-ranked constraints overriding lower-ranked ones in cases of conflict. Take two constraints, $\mathbb{C}$ and $\mathbb{C}'$, which disagree in the ordering of candidates x and y, $\mathbb{C}$ expressing the preference $x \succ y$ whereas $\mathbb{C}'$ declares that $y \succ x$. If their relative ranking is $\mathbb{C} >> \mathbb{C}'$, then the ordering $x \succ y$ is the one that prevails and contributes to the cumulative ordering. The end result is a full harmonic ordering where one particular candidate stands out as preferred over all others in the set; this is the optimal output.

This more complex interaction among constraints requires a revision of how OT tableaux are depicted visually. The example in (39) illustrates one possible way of representing targeted constraints and their interaction with other constraints.

(39) Indeterminacy problem resolved with targeted →IDENT[+voi]-CC:

/t_1ə́b_2â/	→IDENT[+voi]-CC	IDENT[±voi]-IO
a. $t_{1,x}$ə́$b_{2,x}$â	b ≻ a	
b. ☞ $d_{1,x}$ə́$b_{2,x}$â		(a ≻ b)
c. $t_{1,x}$ə́$p_{2,x}$â		a ≻ c
Harmonic ordering by constraint	b ≻ a	(a ≻ b); a ≻ c
Cumulative harmonic ordering	b ≻ a	☞**b** ≻ a ≻ c

The representation in (39) is a hybrid one, merging the traditional OT tableau with the kind of tableau used, e.g., by Baković & Wilson (2000). Note that a targeted constraint cannot be thought of as 'assigning violation marks' in the usual way. In normal tableaux, a '*' indicates that the candidate in question is worse (less harmonic) than *any and all* candidates which have no '*' in that same column; the same goes for cells with two instances of '*' vis-à-vis those with fewer than two, and so forth (cf. the Cancellation/Domination Lemma of Prince & Smolensky 2004). Targeted constraints are fundamentally different: despite the fact that →IDENT[+voice]-CC deems (39a) to be worse than (39b), it does not declare (39a) to be worse than (39c), nor does it say anything about the relative well-formedness of (39b) and (39c). No distribution of '*' marks across the three tableau cells in the →IDENT[+voice]-CC column will correctly capture this partial harmonic ordering over the three candidate outputs. Instead of '*', the tableau format shown in (39) specifies *which* particular candidate the constraint declares as being more harmonic than the candidate in question; hence the entry 'b ≻ a' in the relevant cell for (39a). For consistency, standard (non-targeted) constraints are dealt with in the same way. The faithfulness constraint IDENT[±voice]-IO defines *any* candidate that is unfaithful to input [±voice] specifications—including both (39b) and (39c)—as less harmonic than *any* candidate that is fully faithful in that respect, such as (39a). That is, the constraint imposes the complete ordering a ≻ {b, c} on the set {a, b, c}; this is indicated here as 'a ≻ b' for (39b) and 'a ≻ c' for (39c), rather than one '*' in each cell.

In the bottom part of the tableau, the harmonic ordering relations imposed by individual constraints are summed up and accumulated. The undominated constraint →IDENT[+voice]-CC contributes only the ordering b ≻ a to the overall harmonic ordering of the candidate set as a whole. As described above, the next constraint in the ranking, IDENT[±voice]-IO, has two pairwise orderings to contribute, a ≻ b and a ≻ c. However, the former of these directly contradicts an ordering imposed by a higher-ranked constraint, and is therefore overridden. For ease of reference, a ≻ b is enclosed in parentheses, precisely to indicate that this ordering is overruled. As a result of this constraint conflict, the only thing that IDENT[±voice]-IO is able to contribute is the ordering a ≻ c. Any genuine contributions a constraint makes to the cumulative ordering are indicated by underlining.

Finally, the bottom row of (39) shows how the total harmonic ordering over the whole candidate set is built up. The first column shows the 'cumulative' ordering given the sole constraint $\rightarrow$IDENT[+voice]-CC; this is simply the ordering b ≻ a imposed by that particular constraint. The second column shows the cumulative ordering given $\rightarrow$IDENT[+voice]-CC >> IDENT[±voice]-IO. Combining the individual orderings b ≻ a and a ≻ c (the underlined ones), we get b ≻ a ≻ c. In this simple example with only three candidates to choose from, we need look no further. Candidate (39b) has at this point been singled out as preferred over (39a) as well as over (39c)—in the latter case by transitivity, as it were—and the designation of (39b) as the optimal output is indicated with the usual pointing-finger symbol.

This concludes our introduction to the fundamental aspects of the correspondence-based agreement analysis of consonant harmony proposed in this work. In the remainder of this chapter we will see how, given this basic framework, a wide range of effects observed in the cross-linguistic typology of consonant harmony systems (see chapters 2 and 3 above) falls out from constraint interaction.

4.3. Interaction with Faithfulness: Deriving Directionality and Stem Control

In §3.1 it was stated, as an empirical generalization, that all attested consonant harmony systems obey one of two directionality patterns. The difference between the two is a matter of sensitivity to morphological constituent structure; the two types can be characterized as morphology-sensitive vs. morphology-insensitive harmony. In the first case, the directionality of harmony is cyclic ('inside-out'), with affixes assimilating to the stem to which they attach. Following Baković (2000), this type will be referred to as *stem-controlled* harmony. When consonant harmony is not sensitive to constituent structure—such that stem consonants can assimilate to affix consonants—the directionality is always anticipatory (regressive, right-to-left). For simplicity, this pattern will be referred to as *directional* harmony. The generalization may be summarized in observational terms as follows: in suffixation contexts, the stem may assimilate to the suffix (directional harmony) or vice versa (stem-controlled harmony), whereas in prefixation contexts, the prefix may assimilate to the stem (stem-controlled and/or directional harmony) but the stem *never* assimilates to the prefix.

In the preceding sections, the default status of anticipatory directionality was associated with findings in the domain of speech errors and speech planning, and was encoded by means of a strictly right-to-left correspondence relation, $C_1 \leftarrow C_2$. In this section we see how, given these assumptions, the two major directionality patterns fall out from constraint interaction. The analysis of directional (anticipatory) harmony is presented in §4.3.1, and makes crucial use of the idea that IDENT[F]-CC constraints are *targeted*, as discussed in the preceding section. An analysis of stem-controlled harmony is developed in §4.3.2, and it is demonstrated how constraint interaction can give rise to perseveratory (left-to-right) assimilation even in the face of anticipatory (right-to-left) correspondence. Finally, §4.3.3 brings up some potential problem cases, as well as outstanding questions related to the general issue of directionality effects.

4.3.1. Directional Harmony: IDENT[F]-CC as a Targeted Constraint

Our first task is to deal with those consonant harmony systems which were the motivation for postulating asymmetric $C_1 \leftarrow C_2$ correspondence in the first place: namely those exhibiting absolute (morphology-insensitive) anticipatory directionality. We have already encountered one simple example of this kind of directionality: obstruent voicing harmony in Ngizim (see §2.4.7 and §4.2.3 above), where [+voice] was transmitted from a voiced obstruent to a *preceding* obstruent but never to a following one. Since that harmony operates morpheme-internally, its directionality cannot by definition be governed by constituent structure. In the Ngizim case, we saw how the strict anticipatory directionality could be captured by assuming that IDENT[F]-CC constraints are *targeted* constraints. This analysis will be further elaborated and justified in the present section.

Although morpheme-internal harmony cannot by definition be morphology-sensitive (at least not in terms of directionality effects), it would be wrong-headed to describe it as morphology-*insensitive*. In Ngizim voicing harmony, it is not the case that the directionality goes *against* constituent structure—it is merely that constituent structure is irrelevant. Much clearer cases of strict anticipatory directionality are ones in which harmony is enforced in hetero-morphemic contexts as well, resulting in surface alternations. A particularly striking example is the well-known sibilant harmony found in many of the Chumashan languages (see §2.4.1.1 and §3.1.2 above for detailed discussion and references). This is illustrated by the Ineseño examples in (40); the stem is here indicated in boldface.

(40) Anticipatory sibilant harmony in Ineseño Chumash (Applegate 1972)

a.	ʃapitʃʰolit	/s-**api-tʃʰo**-it/	‘I have a stroke of good luck’
b.	sapitsʰolus	/s-**api-tʃʰo**-us/	‘he has a stroke of good luck’
c.	ʃapitʃʰoluʃwaʃ	/s-**api-tʃʰo**-us-waʃ/	‘he had a stroke of good luck’

In (40a), the alveolar sibilant of the 3Subj prefix /s-/ assimilates to the [tʃʰ] in the (compound) stem to which it attaches, /-api-tʃʰo-/ (consisting of /-api-/ ‘quick’ + /-tʃʰo-/ ‘good’).[36] Since the trigger is in the stem, this example would be consistent with stem control. However, examples (40b) and (40c) show without any doubt that the anticipatory directionality prevails without regard for constituent structure. The form in (40b) is like (40a), except that instead of 1Obj /-it/ we here have the 3Obj suffix /-us/. The alveolar sibilant of this suffix triggers har-

[36] The suffix /-it/ is the 1Obj marker; a more literal translation might perhaps be ‘a stroke of good luck befalls me’. The epenthesis of [l] in hiatus contexts is a regular phenomenon, but is irrelevant here.

mony on any preceding sibilant, regardless whether it is found in the stem (/-api-tʃʰo-/) or in another affix (/s-/). Finally, (40c) clearly demonstrates the recursive nature of this 'outside-in' effect. When the past tense suffix /-waʃ/ is added to the morpheme string in (40b), the [ʃ] of this suffix causes all preceding sibilants to become [–anterior].

Since the harmony in (40) is triggered by [–anterior] and [+anterior] sibilants alike, it is clear that both IDENT[+ant]-CC and IDENT[–ant]-CC must be highly ranked. In what follows, I conflate these into a single IDENT[±ant]-CC constraint. The tableau in (41) shows what happens if we attempt to derive the pattern in (40) with IDENT[±ant]-CC as an ordinary *non*-targeted constraint. The presence of a $C_1 \leftarrow C_2$ correspondence relation, indicated by the subscript 'x', is forced by high-ranked CORR-C↔C constraints that are not shown here. For the sake of simplicity, only the stem + suffix portion of the form /s-api-tʃʰo-us/ (40b) is shown; our main interest is in deriving the suffix-to-stem directionality in cases like this.

(41) Ineseño with non-targeted IDENT[±ant]-CC: indeterminate directionality

/…tʃʰo-us/	IDENT[±ant]-CC	IDENT[+ant]-IO	IDENT[–ant]-IO
a. …tʃʰₓolusₓ	*!		
b. ☞ …tsʰₓolusₓ			*
c. ☞ …tʃʰₓoluʃₓ		*	
d. …tsʰₓoluʃₓ	*!	*	*

The derivation in (41) runs into the exact same indeterminacy problem that we encountered with Ngizim voicing harmony in (37) above. IDENT[±ant]-CC alone is unable to distinguish between anticipatory (41b) and perseveratory harmony (41c); neither of these candidates violates the constraint. Under these conditions, the choice between the two will fall to lower-ranked constraints that have nothing to do with sibilant harmony as such. For example, (41c) would outperform (41b) on stem faithfulness (see §4.3.2 below), since it preserves the stem-internal sibilant /tʃʰ/ intact.

Furthermore, unlike the Ngizim case, we do not even have the option of forcing the choice of (41b) over (41c) by emulating the ranking schema in (36), stipulating the ranking IDENT[+ant]-IO >> IDENT[–ant]-IO. To be sure, this would select the right winner in (41), since a change [+ant] → [–ant] as in (41c) would then be penalized more severely than the change [–ant] → [+ant] as in (41b). But as a general analysis of Ineseño sibilant harmony, this solution achieves at best a 50% success rate. For underlying [+ant]…[–ant] sequences, such as in /k-sunon-ʃ/ → [kʃunotʃ] 'I am obedient', such an analysis wrongly predicts *perseveratory* (left-to-right) harmony, *[ksunots]. The prediction is that the [–anterior] sibilant will always assimilate to its [+anterior] neighbor, regardless of the linear order of the two; when given the choice, [+ant] specifications are preserved at the expense of [–ant] ones.

The fundamental property of Ineseño sibilant harmony that any analysis needs to capture is the fact that the rightmost sibilant always wins out, regardless whether it is [–anterior] or

[+anterior]. In [–ant]…[+ant] sequences, the 'spreading' value is [+ant], as in (41b); In sequences of the [–ant]…[+ant] type, on the other hand, the 'spreading' value is [–ant] (as in the /k-sunon-ʃ/ → [kʃunotʃ] example). Any attempt to resolve the indeterminacy problem in (41) must do so by somehow favoring the suffixal /s/ *not* because it is [+anterior], but merely because it follows its rival /$tʃ^h$/ rather than precedes it. Given the asymmetric correspondence relation $C_1 \leftarrow C_2$, we must somehow force C_1 (the correspondent) to yield to C_2 (the 'source' of correspondence). This is precisely what a targeted-constraint analysis achieves. Before showing how the Ineseño facts can be captured by such an analysis, let us briefly review the properties of the targeted-constraint analysis of consonant harmony.

First of all, consider the definition of IDENT[–ant]-CC and IDENT[+ant]-CC. (At this point, it is most useful to go back to treating these two 'halves' of IDENT[±anterior]-CC as distinct constraints again.) Recall once again that CC correspondence is asymmetric, $C_1 \leftarrow C_2$. Thus IDENT[+ant]-CC requires C_1 to be [+ant] if C_2 is [+ant], whereas IDENT[–ant]-CC requires C_1 to be [–ant] if C_2 is [–ant]. If we think of constraints as propositions with truth values (true = satisfied, false = violated), then each of these is best understood as a *conditional* proposition:

(42) a. IDENT[+anterior]-CC

$P \Rightarrow Q$ ('if P, then Q'), where:

P: ($C_1 \leftarrow C_2$ & C_2=[+ant]);

Q: C_1=[+ant].

b. IDENT[–anterior]-CC

$P \Rightarrow Q$ ('if P, then Q'), where:

P: ($C_1 \leftarrow C_2$ & C_2=[–ant]);

Q: C_1=[–ant].

If the antecedent P is true, the consequent Q must also be true in order for the constraint to be satisfied. Any candidate for which P & ¬Q violates IDENT[±ant]-CC, whereas a candidate with P & Q satisfies it. The constraint is also satisfied (vacuously) if P is *false*, i.e. ¬P, in which case it does not matter if Q is true or not.

In light of this conception of IDENT[±ant]-CC, let us revisit the tableau in (41), repeated in somewhat modified form as (43) below. The violation marks ('*') and satisfaction marks ('✓') for the two IDENT[ant]-CC constraints are accompanied by information on the truth values of P and Q for the candidate in question. Since, as explained above, the relative ranking of IDENT[+ant]-IO against IDENT[–ant]-IO cannot possibly be involved in consistently selecting the correct outputs, I have collapsed the two for simplicity into a single constraint IDENT[±ant]-IO.

(43) Ineseño: indeterminacy problem revisited

/…tʃʰo-us/	IDENT[+ant]-CC	IDENT[–ant]-CC	IDENT[±ant]-IO
a. …$tʃ^h{}_x$olus$_x$	*! (P & ¬Q)	✓ (¬P)	✓
b. ☞ …$ts^h{}_x$olus$_x$	✓ (P & Q)	✓ (¬P)	*
c. ☞ …$tʃ^h{}_x$oluʃ$_x$	✓ (¬P)	✓ (P & Q)	*
d. …$ts^h{}_x$oluʃ$_x$	✓ (¬P)	*! (P & ¬Q)	**

The translation of the '*' and '✓' marks into truth-values of P and Q brings out an important pattern. With respect to their performance on the two IDENT[ant]-CC constraints, candidates (43a–b) form one closely related pair, and (43c–d) form another pair. Each of these constraints states that when a particular state of affairs P is met, Q is allowed whereas ¬Q constitutes an ill-formed (marked) state. (Recall that Q is a proposition specifically about the properties of C_1.) From the point of view of IDENT[+ant]-CC, (43a) and (43b) both meet the P criterion and are exactly identical in all respects, with the sole difference that Q holds true for (43b) but not for (43a). Similarly, from the point of view of IDENT[–ant]-CC (43c) and (43d) are exactly identical, except for the fact that Q holds for (43c) but not for (43d).

There is thus a sense in which, out of the two assimilation options (43b–c), only (43b) is 'comparable' to faithful (43a) in that both satisfy the antecedent P of an IDENT[ant]-CC constraint. By contrast, (43c) is not comparable to (43a) in the same way: it does not meet the antecedent P of that same constraint (though it satisfies the P condition of the other IDENT[ant]-CC constraint). From this perspective, we can say that it is only (43b) that is outright 'better' than (43a), rather than both (43b) and (43c) being 'better' than (43a), as the '✓' vs. '*' marks would suggest. If only we could capture this notion directly in the way the IDENT[ant]-CC constraints are evaluated, (43b) would win. Fully faithful (43a) is the one that otherwise does best; hence, if (43b) *alone* were to outdo (43a) on one of the top-ranked IDENT[ant]-CC constraints, (43b) would emerge as optimal, which is the correct outcome.

This is precisely what we achieve by redefining IDENT[F]-CC constraints as *targeted* constraints. From the perspective of such constraints as conditional propositions in (42), →IDENT[ant]-CC can be understood as nothing more than a contextual well-formedness constraint: 'given the context P, Q is preferred over ¬Q'. What the constraint 'targets' is then the ill-formed state of affairs: *¬Q in the context P*. One way to formulate →IDENT[ant]-CC is to separate out a (contextual) markedness statement, a kind of 'grounding condition' (Archangeli & Pulleyblank 1994) about [anterior] agreement under CC correspondence. Let us refer to this markedness statement as CC/[ANT]:

(44) CC/[ANT] (contextual markedness statement)

a. Given a pair of corresponding output consonants, $C_1 \leftarrow C_2$, where C_2 is [αanterior], then

b. [αanterior] is unmarked for C_1 (and [–αanterior] is marked).

CC/[ANT] consists of two components: a *context* (44a) and a markedness (or 'ill-formedness') statement (44b) which applies in that particular context. These are equivalent to our P and Q, respectively, in (42)–(43). The formulation clearly brings out the notion that it is specifically an disagreeing *correspondent* consonant (C_1) that is marked, rather than the sequence C_1[–αant]…C_2[αant] as a whole. We can now define our targeted →IDENT[ant]-CC constraint with reference to CC/[ANT]:[37]

(45) →IDENT[ant]-CC

Candidate x' is preferred over x ($x' > x$) iff x contains a consonant C_i which is marked with respect to CC/ANT, and x' is exactly like x except in that the same C_i is unmarked with respect to CC/ANT.

Since we have been viewing (→)IDENT[+ant]-CC and (→)IDENT[–ant]-CC as two distinct constraints, (44) should, to be precise, be separated into two markedness statements, which we can call CC/[+ANT] (for C_2 = [+anterior]) and CC/[–ANT] (for C_2 = [–anterior]), respectively. Each of these constitutes the relevant grounding condition for a value-specific targeted constraint; for example, →IDENT[+ant]-CC is defined as in (45) but with reference to CC/[+ANT] specifically.

In order to qualify as the x and x' pair referred to in (45), the two candidate outputs must be completely identical in all respects, except that they *differ in the [anterior] value of C_1*. Most importantly, the [±anterior] value of C_2 *must* be identical across the two candidates in order for the →IDENT[ant]-CC constraint to have anything to say about their relative well-formedness. Candidates with [–ant]…[+ant] and [+ant]…[–ant] are not comparable to each other, since they differ not only in the *targeted* element (C_1) but also in some other respect (namely C_2). The same is true of a pair like [–ant]…[+ant] and [–ant]…[–ant]; with respect to the targeted element (C_1), the two are identical, but they differ in other respects (C_2). The only pairs that will qualify as x' vs. x in the definition in (45) are [–ant]…[+ant] vs.

[37] Admittedly, when formulated in this way, IDENT[F]-CC constraints start to look less like other correspondence constraints, and more like markedness constraints. This is perhaps not surprising. As has already been pointed out, IDENT[F]-CC constraints *are* technically Markedness constraints, in that what they evaluate are properties of the output representation as such, not the 'faithfulness' of that representation to some other representation (see McCarthy 2006).

[+ant]…[+ant] on the one hand (for the purposes of →IDENT[+ant]-CC) and [+ant]…[–ant] vs. [–ant]…[–ant] on the other (for →IDENT[–ant]-CC).

When recast in this manner, the Ineseño indeterminacy problem from (43) is resolved as shown in (46).

(46) Ineseño: indeterminacy resolved with targeted →IDENT[ant]-CC constraints:

/…tʃ^{h}o-us/	→ID[+ant]-CC	→ID[–ant]-CC	ID[±ant]-IO
a. …tʃ$^{h}{}_{x}$olus$_{x}$	b ≻ a		
b. ☞ …ts$^{h}{}_{x}$olus$_{x}$			(a ≻ b)
c. …tʃ$^{h}{}_{x}$oluʃ$_{x}$			a ≻ c
d. …ts$^{h}{}_{x}$oluʃ$_{x}$		c ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>	<u>c ≻ d</u>	(a ≻ b); <u>a ≻ c</u>; <u>a ≻ d</u>; <u>b ≻ d</u>; c ≻ d
Cumulative harmonic ordering	b ≻ a	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d

Undominated →IDENT[+ant]-CC prefers (46b) over (46a). The same goes for (46c) vs. (46d) with respect to undominated →IDENT[–ant]-CC. Hence the preference relations b ≻ a and c ≻ d are contributed to the cumulative harmonic ordering of candidates. This already tells us that neither (46a) nor (46d) can possibly be optimal, since each is dispreferred relative to some other candidate.

How (46b) ends up being preferred over (46c) is somewhat more subtle. In fact, *none* of the three constraints in (46) express a preference for (46b) over (46c)—that is, no individual constraint is evaluating (46c) as 'more marked' than (46b). The deciding constraint is in fact the IO faithfulness constraint IDENT[±ant]-IO, but not in the sense that (46b) is somehow 'more faithful' than (46c). Given the pairwise orderings b ≻ a and c ≻ d, it is enough that a constraint (such as IDENT[±ant]-IO) count *some* candidate as more harmonic than (46c)—without penalizing (46b) at the same time—in order for the tie between (46b) and (46c) to be broken. This is exactly what happens. IDENT[±ant]-IO contributes the relation a ≻ c to the cumulative harmonic ordering, but is prevented to do the same in for a ≻ b, due to conflict with a higher-ranked constraint), and this is what ultimately renders (46c) sub-optimal, leaving (46b) as the optimal candidate.

In other words, the preference for anticipatory over perseveratory assimilation ('b ≻ c') *emerges* from the accumulation of individual harmonic orderings—by transitivity, as it were. Candidate (46b) is optimal not because it outdoes (46c) on any individual constraint, but because it is preferred over (46a), which in turn is preferred over (46c). True, the particular constraint which prefers (46a) over (46c) likewise prefers (46a) over (46b) *in principle*, but the latter preference is overridden by a higher-ranked constraint. The interaction between the

IDENT[F]-CC and IDENT[F]-IO constraints can be paraphrased as follows: anticipatory harmony is better than faithful disharmony, but faithful disharmony is better than any harmony at all. At first glance, this sounds contradictory, because it fails to capture the fact that the preference of anticipatory harmony over faithful disharmony *cancels out* one half of the general preference of faithful disharmony over any kind of harmony. The net result is thus: anticipatory harmony is better than faithful disharmony, which is in turn better than perseveratory harmony. This is parallel to Baković & Wilson's (2000) analysis of high-vowel transparency in Wolof [ATR] harmony. There the interaction of →NO(HI,ATR) with the lower-ranked AGREE(ATR) constraint could be paraphrased, somewhat counter-intuitively, as this: disharmony-by-transparency ([ɛ-i-ɔ]) is better than full harmony ([ɛ-ɪ-ɔ]), which in turn is better than any kind of disharmony.[38] Once constraint conflicts are resolved, by higher constraints overriding lower ones, the net result is that disharmony-by-transparency ([ɛ-i-ɔ]) is better than full harmony ([ɛ-ɪ-ɔ]), which is in turn better than disharmony-by-opacity ([ɛ-i-o]).

We have now solved the indeterminacy problem in (43), and showed how the preference of anticipatory over perseveratory harmony emerges from the interaction of targeted →IDENT[F]-CC constraints with Input-Output faithfulness constraints. The Ineseño example in (46) resulted in [+anterior] being transmitted from C_2 to C_1. The tableau in (47) demonstrates that the anticipatory directionality is independent of the feature value involved: if C_2 is [–anterior], then C_1 will surface as [–anterior] as well. The derivation shows /k-sunon-ʃ/ → [kʃunotʃ] 'I am obedient' (/k-/ 1Subj, /-sunon-/ 'obey', /-ʃ/ stative).

(47) Ineseño: anticipatory [–anterior] harmony (suffix-to-stem example)

/k-sunon-ʃ/	→ID[+ant]-CC	→ID[–ant]-CC	ID[±ant]-IO
a. ks$_x$unotʃ$_x$		b ≻ a	
b. ☞ kʃ$_x$unotʃ$_x$			(a ≻ b)
c. ks$_x$unots$_x$			a ≻ c
d. kʃ$_x$unots$_x$	c ≻ d		{a, b, c} ≻ d
Harmonic ordering by constraint	c ≻ d	b ≻ a	(a ≻ b); a ≻ c; a ≻ d; b ≻ d; c ≻ d
Cumulative harmonic ordering	c ≻ d	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d

[38] This is a slight oversimplification; Baković & Wilson's (2000) analysis requires appealing to an independent principle from targeted constraint theory, known as Priority of the More Harmonic. This need not concern us here, but will become relevant shortly (see (51) below).

In (47), the stative suffix /-ʃ/ triggers [–anterior] agreement in the stem, just as the 1Obj suffix /-us/ triggered [+anterior] harmony in (46).[39] As in (46), the choice of anticipatory over perseveratory assimilation falls out from the cumulative interaction of targeted IDENT[F]-CC (operating over a strictly anticipatory correspondence relation) and IDENT[F]-IO. Ineseño sibilant harmony is thus strictly directional, with the right-to-left directionality prevailing even when it goes against constituent structure (the stem yielding to the affix rather than vice versa).

Before leaving the topic of directional harmony, we must assure ourselves that this analysis is also capable of accounting for the *iterativity* of sibilant harmony in languages like Ineseño. The rightmost sibilant consistently imposes its [±anterior] value on any and all preceding sibilants, regardless of their number or of their underlying [±anterior] specifications. The tableau in (46) accounted for the derivation /…tʃ^{h}o-us/ → […ts^{h}olus], as in [sapits^{h}olus] 'he has a stroke of good luck' in (40b). When the past-tense marker /-waʃ/ is added, the /ʃ/ of this suffix becomes the harmony trigger, with the result that all preceding sibilants surface as [–anterior]: /…tʃ^{h}o-us-waʃ/ → […tʃ^{h}oluʃwaʃ], as in (40c) [ʃapitʃ^{h}oluʃwaʃ] 'he had a stroke of good luck'. The forms in (48) further illustrate the iterative nature of the harmony.

(48) Iterative sibilant harmony in Ineseño Chumash (data from Applegate 1972)

a.	ʃitʃ'iwiʃutʃ	/s-ts'iwis-Vtʃ/	'he plays the rattle'
b.	ʃluʃiʃiniwaʃ	/s-lu-sisin-waʃ/	'it is all grown awry'

In (48a), the /tʃ/ of the verbalizing suffix /-Vtʃ/ forces all three preceding [+anterior] sibilants to surface as [–anterior] by sibilant harmony. In (48b), the same is true of the /ʃ/ of the past-tense suffix /-waʃ/.[40]

The derivation /s-ts'iwis-Vtʃ/ → [ʃitʃ'iwiʃutʃ] is shown in (49) below. Since our interest is specifically in generating the correct sibilant harmony pattern, some irrelevant details are ignored ([i]-epenthesis, and the realization of underspecified /V/ as [u]). As the input contains four sibilants, the number of candidates we need to consider is greater than in any of the tableaux encountered so far; as a result, the tableau in (49) is somewhat cluttered. With respect to CC correspondence, the sequence of four sibilants has here been broken down into three local pairs of corresponding sibilants: $S_x…S_{x,y}…S_{y,z}…S_z$, which contains the three pairs $S_x…S_x$, $S_y…S_y$ and $S_z…S_z$. Each of the three local pairs is potentially relevant to $^{\rightarrow}$IDENT[ant]-CC. (The question of how correspondence relations among such *n*-tuples of segments are to be

[39] The predictable realization of /n+ʃ/ as [tʃ] in (47) is ignored here (cf. /k-sunon-us/ → [ksunonus] 'I obey him').

[40] To be precise, the initial [ʃ] in (48b) (from 3Subj /s-/) would in fact surface as such regardless of sibilant harmony, due to the so-called 'precoronal effect', whereby /s/ → [ʃ] before the non-sibilants [t, l, n]. The interaction of this effect with sibilant harmony is discussed in detail in §5.1.1 below.

understood will be revisited below.) As in previous tableaux, the relevant (high-ranked) CORR-C⇔C constraints have here been left out for simplicity, and only candidates with the appropriate correspondence configuration are displayed.

(49) Ineseño: anticipatory [±anterior] harmony is iterative

/s-ts'iwis-Vtʃ/	→IDENT[–ant]-CC	IDENT[±ant]-IO
a. s$_{x}$its'$_{x,y}$iwis$_{y,z}$utʃ$_{z}$	b ≻ a	
b. s$_{x}$its'$_{x,y}$iwiʃ$_{y,z}$utʃ$_{z}$	c ≻ b	(a ≻ b)
c. s$_{x}$itʃ'$_{x,y}$iwiʃ$_{y,z}$utʃ$_{z}$	d ≻ c	({a, b} ≻ c); e ≻ c
d. ☞ ʃ$_{x}$itʃ'$_{x,y}$iwiʃ$_{y,z}$utʃ$_{z}$		({a, b, c} ≻ d); e ≻ d
e. s$_{x}$its'$_{x,y}$iwis$_{y,z}$uts$_{z}$		a ≻ e
Harmonic ordering by constraint	d ≻ c; c ≻ b; b ≻ a	(a ≻ b); (a ≻ c); (a ≻ d); (b ≻ c); (b ≻ d); (c ≻ d); a ≻ e; (e ≻ c); (e ≻ d)
Cumulative harmonic ordering	d ≻ c ≻ b ≻ a	☞**d** ≻ c ≻ b ≻ a ≻ e

Candidates (49a–d) represent a scale from completely faithful to fully harmonized: [s…ts'…s…ʃ] (49a), [s…ts'…ʃ…ʃ] (49b), [s…tʃ'…ʃ…ʃ] (49c), [ʃ…tʃ'…ʃ…ʃ] (49d). Candidate (49e) employs the alternative strategy of perseveratory harmony: [s…ts'…s…s]. In that case, the first three [+anterior] sibilants have, as it were, 'ganged up' on the rightmost [–ant] sibilant. Note that →IDENT[+ant]-CC has been left out here, as it has nothing to say about the relative well-formedness of any of (49a–e) vis-à-vis each other, and hence makes no contribution to the eventual outcome of the derivation. That constraint would prefer (49e) over the bizarre option [s$_{x}$its'$_{x,y}$iwiʃ$_{y,z}$uts$_{z}$], in which the underlying [–ant] value of the final sibilant has effectively been 'flopped' onto the preceding sibilant. (This is comparable to the (47c) vs. (47d) comparison above.) That bizarre '[–anterior]-flop' candidate would stand no chance of winning the competition in (49), and hence the mere fact that (49e) outdoes that candidate on →IDENT[+ant]-CC will not help promote the latter in any significant way.

The status of (49d) as optimal hinges on the fact that, of the several pairwise harmonic orderings expressed by IDENT[±ant]-IO, a ≻ e gets contributed to the cumulative ordering (making (49d) beat (49e) 'by transitivity', just like in (47) above) but not e ≻ d (which would have resulted in (49e) being optimal). Before explaining how this comes about, let us first consider how →IDENT[–ant]-CC is evaluated. In order for two candidates to be comparable by this constraint, they must differ in the [±anterior] specification of *a single sibilant*, namely the C_1 member of a C_1←C_2 correspondence pair, in which C_1 is [–anterior]. Consider (49b) and (49c), which contain the sequences [s$_{x}$…ts'$_{x,y}$…ʃ$_{y,z}$…ʃ$_{z}$] and [s$_{x}$…tʃ'$_{x,y}$…ʃ$_{y,z}$…ʃ$_{z}$], respectively. These differ only in their second sibilant ([ts'] vs. [tʃ']), which moreover is the C_1

member of the $S_y…S_y$ correspondent pair ([ts'$_y$…ʃ$_y$] vs. [tʃ'$_y$…ʃ$_y$]), in which C_2 ([…ʃ$_y$]) is an [–anterior] sibilant. Since this C_1 matches its C_2 counterpart in terms of [–anterior] in (49c), but not in (49b), $\rightharpoonup$IDENT[ant]-CC prefers (49c) over (49b). Hence the ordering c ≻ b in the relevant cell for (49b). But note that (49c) is *also* comparable to (49d): the latter contains the sequence [ʃ$_x$…tʃ'$_{x,y}$…ʃ$_{y,z}$…ʃ$_z$] as opposed to [s$_x$…tʃ'$_{x,y}$…ʃ$_{y,z}$…ʃ$_z$] in (49c). These two candidates likewise differ in only one segment, the first sibilant ([ʃ] vs. [s]), which is the C_1 member of the $S_x…S_x$ correspondent pair ([ʃ$_x$…tʃ'$_x$] vs. [s$_x$…tʃ'$_x$]). In this comparison, candidate (49d) is preferred over (49c), C_1 agrees with C_2 in terms of [–anterior] in the former but not the latter. This gives us the ordering d ≻ c. $\rightharpoonup$IDENT[–ant]-CC also imposes the ordering b ≻ a in the same way (with respect to the $S_z…S_z$ correspondent pair), and the full range of harmonic ordering relations imposed by $\rightharpoonup$IDENT[–ant]-CC is therefore d ≻ c ≻ b ≻ a.

As for (49e), it contains [s$_x$…ts'$_{x,y}$…s$_{y,z}$…s$_z$], and thus differs from the faithful candidate [s$_x$…ts'$_{x,y}$…s$_{y,z}$…ʃ$_z$] (49a) in only one segment: the final sibilant ([s] vs. [ʃ]). Why does $\rightharpoonup$IDENT[–ant]-CC (or $\rightharpoonup$IDENT[+ant]-CC, for that matter) not have anything to say about the pair (49e) vs. (49a)? This is because the sibilant in question does not qualify as a *target* for either $\rightharpoonup$IDENT[–ant]-CC or $\rightharpoonup$IDENT[+ant]-CC; these constraints only target a consonant that constitutes the *C_1* member of some $C_1 \leftarrow C_2$ correspondence pair (and which disagrees with its C_2 counterpart in terms of [±anterior]). The last sibilant of a word is obviously not the C_1 member of any such pair (and it is completely irrelevant that it is the *C_2* member of one such pair). For this reason, the $\rightharpoonup$IDENT[ant]-CC constraints neither prefer nor disprefer (49e) over (49a)—nor over any of the other candidates either, for that matter.

The net contribution of the $\rightharpoonup$IDENT[ant]-CC constraints to the cumulative ordering of candidates in (49) is thus d ≻ c ≻ b ≻ a. At this point, it is clear that only (49d) or (49e) are in the running for optimal-output status. It falls to lower-ranked IDENT[±ant]-IO to decide whether consistent anticipatory harmony (49d) will prevail, or whether 'ganging-up' of the three [+anterior] sibilants will result in perseveratory harmony (49e). At first glance, it would appear obvious that (49e) should win, since IDENT[±ant]-IO explicitly dictates the ordering e ≻ d; after all, (49d) violates IO faithfulness three times but (49e) only once. Things are not quite so simple, however. IDENT[±ant]-IO also states the preference a ≻ e. Neither a ≻ e nor e ≻ d is *individually* inconsistent with the cumulative ordering established at that point (d ≻ c ≻ b ≻ a), but they are *mutually* inconsistent with it. Adding both a ≻ e and e ≻ d to the cumulative ordering would result in a vicious circle, in which every candidate is worse than some other candidate. This is shown schematically in (50), where, for purely typographical reasons, '≻' has been replaced by '→'.

(50) Vicious circle of harmonic orderings (if a ≻ e and e ≻ d are both added):

d
↙ (↖)
c
↓ e
b
↘ (↗)
a

If circular orderings such as (50) were allowed to arise, the derivation would simply crash, as none of the candidates could be defined as optimal. Since a ≻ e and e ≻ d cannot *both* be added to the cumulative ordering, we must choose one or the other on some principled grounds. The theory of targeted constraints (Wilson 2000, 2001) provides a general rule for resolving harmonic-ordering paradoxes of this kind:

(51) Priority of the More Harmonic (Wilson 2001)

Let C be any constraint, and let *x* ≻ *y* and *x*′ ≻ *y*′ be any two harmonic orderings asserted by C. If *x* is more harmonic than *x*′ according to the hierarchy (i.e. if the highest-ranked constraint that prefers one of the candidates over the other favors *x*), then *x* ≻ *y* takes priority over *x*′ ≻ *y*′ when adding both of them to the cumulative harmonic ordering would lead to circularity.

How does this apply to our situation in (49)? Undominated →IDENT[–ant]-CC has already established that d ≻ c ≻ b ≻ a. The two orderings a ≻ e and e ≻ d are mutually inconsistent with this ordering, as shown in (50). Priority of the More Harmonic dictates that a ≻ e will take priority over e ≻ d iff the constraint hierarchy judges (49a) to be more harmonic than (49e), as these two are equivalent to *x* and *x*′ in the definition in (51). We must therefore look for the highest-ranked constraint that compares (49a) against (49e). This is IDENT[±ant]-IO itself, which clearly asserts a ≻ e.[41] Therefore, of the two competing orderings a ≻ e and e ≻ d, only a ≻ gets added to the cumulative ranking (as indicated by underlining). The ordering e ≻ d is ignored/overridden (indicated by the parentheses); the same applies to e ≻ c, which is mutually inconsistent with a ≻ e in the same way (given c ≻ b ≻ a). The end result is then that the sole contribution of IDENT[±ant]-IO to the cumulative ordering is a ≻ e. All the other orderings asserted by this constraint are either directly overridden by ones arising from higher-ranked →IDENT[–ant]-CC or they are ruled out by (51). Combining a ≻ e with d ≻ c ≻ b ≻ a,

[41] It is of no significance here that this a ≻ e relation happens to be one of the two 'competing' orderings under consideration (a ≻ e vs. e ≻ d). An exactly parallel situation in Wolof [ATR] harmony is discussed by Baković & Wilson (2000).

the complete ordering is d ≻ c ≻ b ≻ a ≻ e. The winner is (49d); iterative anticipatory harmony prevails over all alternatives.

As noted above, the analysis laid out above presupposed that, in terms of correspondence configurations, *n*-tuples of corresponding segments be treated as ‘chains’ of local correspondence pairs. A four-sibilant sequence like the one in (49) was thus not treated as [S_x…S_x…S_x…S_x]—which contains a total of *six* distinct [S_x…S_x] pairs—but rather as [S_x…$S_{x,y}$…$S_{y,z}$…S_z], with only three correspondent pairs for $^{\rightarrow}$IDENT[ant]-CC constraints to evaluate. In his analysis of Chumash sibilant harmony (which builds on that in Hansson 2001, preserved here mostly unchanged), McCarthy (2006) suggests that configurations of this kind, in which a segment may be, as he puts it, ‘assigned to two different correspondence domains simultaneously’ are unnecessary, adding that they ‘can perhaps be dispensed with universally’. Certainly, allowing $^{\rightarrow}$IDENT[ant]-CC to evaluate correspondence ‘globally’ over a [S_x…S_x…S_x…S_x] structure, rather than ‘locally’ over a [S_x…$S_{x,y}$…$S_{y,z}$…S_z] structure, would not affect the outcome in (49). However, the notion of distinct ‘correspondence domains’ is something of a red herring. The CORR-C↔C constraints that impose correspondence relations on the output assess individual *pairs* of segments. There is no implicit understanding that if A is a correspondent of B, and B is a correspondent of C, it must necessarily also be the case that A stands in direct correspondence with C (and is evaluated as such). To draw a parallel with Base-Reduplicant correspondence, an output segment in the Reduplicant may stand in (BR) correspondence with a Base (output) segment, which in turn stands in (IO) correspondence with an input segment; this does not entail that any direct correspondence relation holds between the Reduplicant segment and the relevant (underlying) input segment. A even closer parallel would be double reduplication, such as in Lushootseed (Urbanczyk 2006), where an input /$DIST_{RED}$-DIM_{RED}-bədaʔ/ (with two distinct reduplicant prefix morphemes) surfaces as [b́í-bi-bədaʔ]; the outer Reduplicant matches certain unfaithful aspects of the inner Reduplicant rather than copying the (innermost) Base directly. These kinds of ‘cyclicity’ effects would be difficult to capture if BR correspondence relations are necessarily transitive; there is no reason to assume that CC correspondence behaves any differently.[42]

Moreover, Hansson (2006a, 2007b) has shown that *global* evaluation of IDENT[F]-CC constraints over correspondence chains like [S_x…S_x…S_x…S_x] has various problematic computational and typological consequences, proposing that agreement is evaluated only for the *local* (chain-adjacent) pairs. Rhodes (2008) has further suggested that a locality restriction be built into CORR-C↔C constraints as well (e.g. that presence vs. absence of a correspondence relation only be adjudicated for those sibilant pairs not separated by a sibilant). If one or both

[42] The particular Lushootseed cases discussed by Urbanczyk (2006) and shown here are not a perfect analogue, since she treats the [i] vs. [ə] mismatch between the inner Reduplicant and its Base not as a matter of imperfect correspondence (violations of IDENT[F]-BR) but as ‘underparsing’ and default segmentism (violations of MAX-BR). I am assuming here that the ‘cyclicity’ effects Urbanczyk documents are a property of double reduplication in general, rather than of this particular subtype of Base-Reduplicant mismatches specifically.

of these refinements of the ABC model are adopted, the distinction of $[S_x \ldots S_x \ldots S_x \ldots S_x]$ vs. $[S_x \ldots S_{x,y} \ldots S_{y,z} \ldots S_z]$ becomes largely a notational issue.

To sum up, we have seen in this section that the targeted-constraint analysis correctly derives systems like Ineseño sibilant harmony. The same analysis extends to other harmony systems with morphology-insensitive anticipatory directionality. In the following section, we turn to those consonant harmony systems in which the directionality of assimilation is dictated by morphological constituent structure.

4.3.2. Stem Control: The Emergence of Perseveratory Directionality

As we saw in chapter 3, stem control is a common pattern in the cross-linguistic typology of consonant harmony, just as it is in vowel harmony systems (Baković 2000). Descriptively, stem control is when an affix segment consistently yields to—that is, assimilates to—a segment in the base of affixation, rather than vice versa. The essence of this effect is 'cyclicity' in the following informal sense: harmony is satisfied in a set of successively larger morphological domains, where each domain preserves intact the domain nested within it (the 'stem').

One way to capture cyclicity effects in an output-oriented framework like Optimality Theory is to assume a separate set of faithfulness constraints holding between the output (the affixed form) and the stem of affixation. This is construed as a type of Output-Output correspondence by Benua (1995, 2000 [1997]; cf. also Baković 2000)—a view which presupposes that the stem of affixation actually *occurs* as a free-standing output form in the language in question. Related proposals along similar lines involve Uniform Exponence (Kenstowicz 1996, 1997) or Paradigm Uniformity (Steriade 2000); such constraints could ensure that the realization of the stem of affixation will be 'held constant' across the entire paradigm of affixed forms, forcing the affix to yield to the stem. Yet another approach to cyclicity effects is Sign-Based Morphology (see Orgun 1996, 1997, 1999, Dolbey 1996, Yu 2000a, Orgun & Inkelas 2002, Inkelas & Zoll 2005), which explicitly encodes constituency in terms of branching tree structures. The phonological (OT) grammar relates the phonological representation of each mother node to those of its daughter nodes. In this model, cyclic effects arise from the fact that the phonological constraints are evaluated at each node.

For the purposes of this work, it is not directly relevant which formalization is chosen for capturing cyclicity effects. In order to facilitate comparison with the analysis of stem-control in vowel harmony systems developed in Baković (2000), the Output-Output correspondence approach (Benua 1995, 2000) will be followed in the analyses presented here. Stem control effects are then due to IDENT[F]-SA constraints, which demand that the output (the affixed form) be faithful to its stem of affixation ('S' for stem, 'A' for affixed form). The definition in (52) is taken from Baković (2000).

(52) IDENT[F]-SA (Baković 2000)

A segment in an affixed form [stem + affix] must have the same value of the feature [F] as its correspondent in the stem of affixation [stem].

Note that since affixation is recursive, the stem referred to in (52) may itself be an affixed form; this will be the case in nested constituent structures like [[[root] + $affix_1$] + $affix_2$]. The IDENT[F]-SA constraints evaluate the faithfulness of the stem portion (i.e. the [root + $affix_1$] portion of the root + $affix_1$ + $affix_2$ form) to the surface realization of that stem when it occurs as an independent output form (without $affix_2$).[43]

One example of a stem-controlled consonant harmony system is the sibilant harmony found in many Omotic languages (see §2.4.1.1 above). In Koyra (Hayward 1982), the /s/ of the causative suffix /-(u)s/ assimilates in [±anterior] to a sibilant in the preceding stem, as shown in (53). The (53a) forms show that the suffix sibilant is underlyingly [+anterior]. This sibilant surfaces intact if the stem contains another [+anterior] sibilant (53b), but it assimilates to a [–anterior] stem sibilant (53c).

(53) Stem-controlled sibilant harmony in Koyra causative /-(u)s/ (Hayward 1988)

a.	pug-us-	‘cause to blow’
	taːb-us-	‘cause to count’
	ʔuːʔ-us-	‘cause to sip’
b.	kes-us-	‘cause to go out’
	suːz-us-	‘cause to bless’
	saːts’-us-	‘cause to bite’
c.	dʒaʃ-uʃ-	‘cause to fear’
	goːtʃ-uʃ-	‘cause to pull’
	ʔordʒ-uʃ-	‘make big, increase (trans.)’
	ʃaj-ʃ-	‘cause to urinate’

In Koyra, high-ranked CORR-[ant, voi, cont] forces co-occurring output sibilants to stand in a $C_1 \leftarrow C_2$ correspondence relation, regardless of any differences in [±voice], [±anterior] or [±continuant] (an example of a pair differing in all three features would be [dʒ] vs. [s]). The constraints responsible for enforcing harmony in [±anterior] among corresponding sibilants are the IDENT[ant]-CC constraints. As before, these require that if an output consonant (C_2) is [+anterior], then its preceding CC-correspondent (C_1) must also be [+anterior] (and likewise

[43] In the alternative Sign-Based Morphology model (see above for references), a constraint with the same effect as (52) could be defined as requiring identity between the phonological representation of the mother node (the affixed form) and that of its *head daughter* (the stem of affixation). An advantage of this alternative is that it does not presuppose that the stem occurs as a free-standing output form in the language.

for [–anterior]). The constraint ranking that results in stem-controlled harmony is shown in the tableau in (54). For simplicity, the CC correspondence relation (indicated by the subscript 'x') is taken for granted, though it is of course due to high-ranked CORR-[ant, voi, cont].[44] Here and in subsequent tableaux, the stem referenced by IDENT[F]-SA constraints—the *output* realization of the corresponding un-affixed form—is shown alongside the input representation (of the affixed form). The 'anti-faithful' candidate (54d) is included merely for the sake of completeness, even though it cannot possibly win under any ranking permutation. Note also that the [+anterior] and [–anterior] versions of each IDENT[ant] constraint have been conflated to save space.

(54) Koyra: stem-controlled sibilant harmony (non-targeted IDENT[ant]-CC)

Input: /ʔordʒ-us/ *Stem:* [ʔordʒ-]	IDENT[±ant]-CC	IDENT[±ant]-SA	IDENT[±ant]-IO
a. ʔordʒ$_x$us$_x$-	*!		
b. ʔordz$_x$us$_x$-		*!	*
c. ☞ ʔordʒ$_x$uʃ$_x$-			*
d. ʔordz$_x$uʃ$_x$-	*!	*	**

Note that were it not for IDENT[±ant]-SA, candidates (54b) and (54c) would be tied—the same indeterminacy problem we encountered for Ngizim voicing harmony and Ineseño sibilant harmony earlier in this chapter. It was argued in the previous section that the solution to this indeterminacy problem in the case of systems with absolute directionality was to construe IDENT[F]-CC as *targeted* constraints. In the analyses of Ngizim and Ineseño, this had the effect of forcing anticipatory (regressive, right-to-left) harmony, based on the asymmetry of the $C_1 \leftarrow C_2$ correspondence relation. We must therefore make sure that a derivation such as (54) will still yield the right result, with perseveratory (progressive, left-to-right) harmony, even when the IDENT[±ant]-CC constraints are interpreted as targeted constraints.

[44] As mentioned in §2.4.1.1, sibilant harmony in Koyra is subject to a stringent proximity restriction: the trigger and target must be separated by no more than one vowel (i.e. they must be in adjacent syllables). Although this detail is ignored here, it would be captured in the analysis by assuming that in Koyra, IDENT[±ant]-IO intervenes between the C-v-C and C-∞-C versions of *each* of the CORR-C↔C constraints:

$$\left\{\begin{array}{l}\text{CORR-[ant]}_{\text{C-v-C}}\\ \text{CORR-[ant, voi]}_{\text{C-v-C}}\\ \text{CORR-[ant, cont]}_{\text{C-v-C}}\\ \text{CORR-[ant, voi, cont]}_{\text{C-v-C}}\\ \ldots\end{array}\right\} \gg \text{IDENT[}\pm\text{ant]-IO} \gg \left\{\begin{array}{l}\text{CORR-[ant]}_{\text{C-}\infty\text{-C}}\\ \text{CORR-[ant, voi]}_{\text{C-}\infty\text{-C}}\\ \text{CORR-[ant, cont]}_{\text{C-}\infty\text{-C}}\\ \text{CORR-[ant, voi, cont]}_{\text{C-}\infty\text{-C}}\\ \ldots\end{array}\right\}$$

This is demonstrated in (55), using the representational conventions explained in the previous section. Note that, as in (54), IDENT[+ant] and IDENT[–ant] constraints have been conflated. This is the case for the targeted →IDENT[ant]-CC constraints as well; thus, the preference (55b) ≻ (55a) is due to →IDENT[+ant]-CC whereas the (55c) ≻ (55d) ordering is due to →IDENT[–ant]-CC.

(55) Koyra: stem-controlled sibilant harmony with targeted →IDENT[ant]-CC

Input: /ʔordʒ-us/ *Stem:* [ʔordʒ-]	→ID[±ant]-CC	ID[±ant]-SA	ID[±ant]-IO
a. ʔordʒ$_x$us$_x$-	b ≻ a		
b. ʔordz$_x$us$_x$-		(a ≻ b); c ≻ b	(a ≻ b)
c. ☞ ʔordʒ$_x$uʃ$_x$-			(a ≻ c)
d. ʔordz$_x$uʃ$_x$-	c ≻ d	{a, c} ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	(a ≻ b); a ≻ d; c ≻ b; c ≻ d	(a ≻ {b, c}); {a, b, c} ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

The targeted →IDENT[ant]-CC constraints can only compare pairs of candidates, each of which contains a $C_1 \leftarrow C_2$ correspondence pair where C_2 carries a specific value for the feature [±anterior]. For each such pair of candidates, the constraint prefers the one where C_1 has a matching value for [±anterior]. On these grounds, the anticipatory-harmony candidate (55b) is preferred over faithfully disharmonic (55a), whereas the perseveratory-harmony candidate (55c) is only preferred over the 'flop' candidate (55d); in short, b ≻ a and c ≻ d. This leaves (55b) and (55c) alone in the running.

From the point of view of IDENT[±ant]-SA, any candidate that is faithful with respect to the stem sibilant is preferred over any candidate that is not. Translated into pairwise orderings, this means a ≻ b, a ≻ d, c ≻ b and c ≻ d. One of these orderings, c ≻ d, was already imposed by higher-ranked →IDENT[ant]-CC and is thus superfluous; another ordering, a ≻ b, directly contradicts an ordering imposed by the higher-ranked constraint (b ≻ a) and is therefore overridden. What remains as the net contribution of IDENT[±ant]-SA to the cumulative harmonic ordering is then c ≻ b and a ≻ d. The cumulative ordering that results when we combine c ≻ b and a ≻ d with the already-established orderings (b ≻ a and c ≻ d) is c ≻ b ≻ a ≻ d. This exhausts the candidate set under consideration: (55c) emerges as the optimal output. The result is *stem control*, perseveratory sibilant harmony from stem to suffix.

It is worth noting that (55c) fares better than the faithful candidate (55a) despite the fact that no individual constraint prefers (55c) over (55a). In fact, the only constraint that discriminates between the two, IDENT[±ant]-IO, prefers (55a) over (55c). Candidate (55c) outdoes (55a) by *transitivity*, due to the way pairwise harmonic orderings get accumulated. By $^{\rightarrow}$IDENT[±ant]-CC, (55a) is worse than (55b), and by IDENT[±ant]-SA, (55b) is in turn worse than (55c); therefore, by transitivity, (55a) also counts as being worse than (55c): if c ≻ b and b ≻ a, then c ≻ a must hold as well.

The analysis of Koyra sibilant harmony illustrates how perseveratory (progressive, left-to-right) assimilation can emerge from constraint interaction. This in spite of the fact that the CC correspondence relation is by definition an *anticipatory* mapping ($C_1 \leftarrow C_2$), and that the targeted-constraint analysis explicitly favors 'repairing' disharmony by means of anticipatory rather than perseveratory assimilation, other things being equal. Not surprisingly, the same constraint ranking is also able to derive stem control in [prefix + stem] contexts, where inside-out application is indistinguishable from the default anticipatory directionality. One example is the sibilant harmony found in many Athapaskan languages, as illustrated by the two Navajo forms in (56); the root (or 'stem') portion is indicated in boldface.

(56) Navajo sibilant harmony (data from McDonough 1991)

a.	dʒiʃtaːl	/dz-iʃ-l-**taːl**/	'I kick him [below the belt]'
b.	dzists'in	/dz-iʃ-l-**ts'in**/	'I hit him [below the belt]'

In (56a), the /ʃ/ of the 1SgSubj prefix /-iʃ-/ triggers harmony in the preceding adverbial prefix /dz-/. In (56b), the ultimate trigger of harmony is the /ts'/ of the verb root (/-ts'in/), to which both prefix sibilants must agree. For the purposes of illustration, I will take the somewhat simplistic view that the constituent structure of the forms in (56) is [dz-[iʃ-[l-taːl]]] and [dz-[iʃ-[l-ts'in]]], respectively.[45] The fusion of the classifier prefix /l-/ with the preceding /ʃ/ will also be ignored, since it has no bearing on sibilant harmony.

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[45] The internal constituent structure of the Athapaskan verb is a matter of debate (see, e.g., Kari 1989, McDonough 1990, Speas 1990, Rice 2000). Within the verb of any Athapaskan language, discontinuous dependencies between morphemes abound, and inflectional prefixes frequently occur 'inside' derivational ones (at least on the simplistic view that right = 'in' and left = 'out'). If we adopt the analysis of the Athapaskan verb presented by Rice (2000), the general anticipatory directionality of sibilant harmony in Navajo and other related languages *cannot* be regarded as 'inside-out' (cyclic), since the relevant prefix string is instead interpreted as forming a *left*-branching structure. If so, then these languages must be seen as exhibiting not stem-controlled harmony but a strict anticipatory harmony that is insensitive to constituent structure (just like in Ineseño Chumash). In light of these concerns, the analysis of Navajo sibilant harmony sketched here should be seen as nothing more than a simple illustration of how constraint interaction *can* give rise to stem control in [prefix + stem] contexts no less than in [stem + suffix] contexts. See also §3.1.2 for discussion of directionality-related issues in Navajo sibilant harmony.

The derivation for (56a) /dz-iʃ-l-taːl/ → [dʒiʃtaːl] is shown in (57). Just as in (55), IDENT[±ant]-SA evaluates the faithfulness of any sibilants located in the stem portion of the output string—in this case the [ʃ] (or [s]) realizing the /ʃ/ of the 1SgSubj prefix /-iʃ-/. In the particular example examined here, the /ʃ/ of /-iʃ-/ is realized faithfully as [ʃ] in the (output) stem in question, so the distinction between input /ʃ/ and output-stem [ʃ] as the source of SA correspondence does not make a difference in this case. It should nevertheless be kept in mind that when the [s] of (57c–d) violates IDENT[ant]-SA, it does so by being unfaithful not to the *input* /ʃ/ of the prefix morpheme /-iʃ-/, but to the *output* [ʃ] in the stem of affixation [-iʃtaːl].

(57) Navajo: stem-controlled sibilant harmony

Input: /dz-iʃ-l-taːl/ *Stem:* [-iʃtaːl]	→ID[±ant]-CC	ID[±ant]-SA	ID[±ant]-IO
a. $dz_x iʃ_x$taːl	b ≻ a		
b. ☞ $dʒ_x iʃ_x$taːl			(a ≻ b)
c. $dz_x is_x$taːl		{a, b} ≻ c	a ≻ c
d. $dʒ_x is_x$taːl	c ≻ d	{a, b} ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	a ≻ c; a ≻ d; b ≻ c; b ≻ d	(a ≻ b); a ≻ c; a ≻ d; b ≻ d; c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d	(b ≻ a ≻ c ≻ d)

The combined effect of the →IDENT[±ant]-CC and IDENT[±ant]-SA constraints is the cumulative ordering b ≻ a ≻ c ≻ d. Note that in this case, none of the individual pairwise orderings asserted by each of these two constraints conflicts with those of the other; both favor configurations in which C_1 assimilates to C_2 rather than vice versa. Candidate (57b) thus emerges as the optimal output, with stem-controlled anticipatory harmony winning out over all other alternatives.

The derivation of (56b) /dz-iʃ-l-ts'in/ → [dzists'in] is slightly more complicated, in that three sibilants are involved. The ultimate harmony trigger is here located in the root (the /ts'/ of /-ts'in/); this sibilant forces its [+anterior] value onto the /ʃ/ of the /-iʃ-/ prefix, and thereby also prevents the latter from triggering [–anterior] harmony on the preceding /dz-/ prefix as in (57). As this example involves recursive affixation, and SA correspondence compares the output of an affixed form to the *output* form of the stem of affixation, we need to consider two separate (but parallel) derivations. First of all, we must determine the optimal output for /-iʃ-l-ts'in/, since this is the stem (or 'base') from the point of view of /dz-/ prefixation. Only with reference to this output stem can we then determine the optimal output for the full affixed form, /dz-iʃ-l-ts'in/. The tableau for /-iʃ-l-ts'in/ is shown in (58). (Again, this derivation abstracts away from the predictable fusion of the /ʃ/ of the subject prefix /iʃ-/ with the immediately following /l/ of the valence prefix /l-/.)

(58) Navajo: determining the output stem for /dz-{iʃ-l-ts'in}/

Input: /-iʃ-l-ts'in/ *Stem:* [-lts'in]	→ID[±ant]-CC	ID[±ant]-SA	ID[±ant]-IO
a. -iʃ$_X$ts'$_X$in	b ≻ a		
b. ☞ -is$_X$ts'$_X$in			(a ≻ b)
c. -iʃ$_X$tʃ'$_X$in		{a, b} ≻ c	a ≻ c
d. -is$_X$tʃ'$_X$in	c ≻ d	{a, b} ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	a ≻ c; a ≻ d; b ≻ c; b ≻ d	(a ≻ b); a ≻ c; a ≻ d; b ≻ d; c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d	(b ≻ a ≻ c ≻ d)

The derivation here is exactly as that in (57). Anticipatory/inside-out harmony (58b) is better than faithful disharmony (58a), and each of these is worse than perseveratory/outside-in harmony (58c), since the latter violates SA faithfulness. The resulting ordering is b ≻ a ≻ c ≻ d, and (58b) is therefore the optimal output: the prefix sibilant /ʃ/ assimilates to the following root sibilant /ts'/.

We have now determined that the (independent) output realization of /-iʃ-l-ts'in/ is [-ists'in]. When the prefix /dz-/ is added to this constituent, the optimal output is determined as in (59). In this case, what IDENT[±ant]-SA evaluates is faithfulness to the output stem we derived in (58), namely [-ists'in]. Any deviation from either (or both) of the two sibilants in that string is penalized by IDENT[±ant]-SA. To simplify the tableau, the only stem-unfaithful candidates considered here are ones which deviate from the [s] belonging to the /-iʃ-/ prefix, rather than the [ts'] of the root.[46]

[46] Note that any candidate with […iʃtʃ'in] would receive *two* violations of IDENT[±ant]-SA, and would not be comparable to any of (59a–d) for the purposes of →IDENT[ant]-CC. Such candidates are therefore bound to be suboptimal.

(59) Navajo: stem-controlled sibilant harmony with multiple affixation

Input: /dz-iʃ-l-ts'in/ *Stem:* [-ists'in]	→ID[±ant]-CC	ID[±ant]-SA	ID[±ant]-IO
a. $dz_x iʃ_{x,y} ts'_y in$	{b, c} ≻ a	{c, d} ≻ a	
b. $dʒ_x iʃ_{x,y} ts'_y in$		{c, d} ≻ b	(a ≻ b)
c. ☞ $dz_x is_{x,y} ts'_y in$			(a ≻ c)
d. $dʒ_x is_{x,y} ts'_y in$	c ≻ d		({a, b} ≻ d); c ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>; <u>c ≻ a</u>; <u>c ≻ d</u>	c ≻ a; <u>c ≻ b</u>; <u>d ≻ a</u>; <u>d ≻ b</u>	(a ≻ b); (a ≻ c); (a ≻ d); (b ≻ d); c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ {a, d}	☞**c** ≻ d ≻ b ≻ a	(c ≻ d ≻ b ≻ a)

The sequence of three sibilants constitutes two correspondence pairs, indicated by distinct subscript indices, e.g. [dz_x…$ʃ_x$] and [$ʃ_y$…ts'_y] in (59a). For the purposes of the targeted →IDENT[anterior]-CC constraints, each of these two sequences counts. For example, targeted →IDENT[–ant]-CC prefers (59b) over (59a), because these two candidates are identical except for the C_1←C_2 sequence: [dz_x…$ʃ_x$] and [$dʒ_x$…$ʃ_x$], respectively. The latter is preferred, as C_1 matches the [–anterior] value of C_2. On the other hand, →IDENT[+ant]-CC prefers (59c) over (59a), due to the fact that those two differ only in their other C_1←C_2 correspondence pair: [$ʃ_y$…ts'_y] vs. [s_y…ts'_y], in which C_2 is [+anterior]. Hence b ≻ a and c ≻ a are both listed under →IDENT[±ant]-CC in (59).

The choice between candidates (59b) and (59c) depends on the contributions of lower-ranked IDENT[±ant]-SA to the overall harmonic ordering. This constraint directly prefers (59c) over (59b), as the latter is unfaithful to the output stem of affixation, [-ists'in]. Combining all of the orderings asserted by top-ranked →IDENT[±ant]-CC and IDENT[±ant]-SA, we get c ≻ d ≻ b ≻ a, which exhausts the candidate set under consideration, and (59c) emerges as the optimal output.

In this section we have seen how stem control—inside-out directionality—can be derived in the generalized ABC analysis of consonant harmony proposed here. It was demonstrated how the interaction of targeted →IDENT[F]-CC constraints with faithfulness to the stem of affixation (IDENT[F]-SA) can give rise to perseveratory (progressive, left-to-right) directionality, even though CC correspondence is explicitly defined as an anticipatory relation. In her analysis of Kera voicing harmony, Walker (2000a, 2001) concluded that the bidirectionality observed there (stem-to-prefix, stem-to-suffix) called for a *symmetric* CC correspondence relation between the consonants in question.[47] The above analysis shows that this is an unnecessary assumption; stem control can be derived regardless of whether CC correspondence is construed as an asymmetric or symmetric relation.

4.3.3. Problematic Directionality Patterns

There exists a small residue of cases in which the observed directionality patterns pose problems for the analysis of consonant harmony developed in the preceding sections. All involve perseveratory (progressive, left-to-right) directionality that is in some way unexpected. In one case, Sundanese, perseveratory harmony appears to have a privileged status over anticipatory harmony, in that Markedness constraints are able to override the latter but not the former. The remaining cases—all of which involve nasal consonant harmony in certain Bantu languages—show perseveratory directionality of a kind that cannot be reduced to stem control.

The case of Sundanese (Malayo-Polynesian) was briefly covered in the discussion of liquid harmony in §2.4.5. That description omitted several important details which are crucial for understanding why this case constitutes a potential problem for the analysis presented in this chapter. In Sundanese, the plural (distributive) marker /-ar-/ is infixed after the root-initial consonant; in this respect, it behaves like many other affixes with -VC- shape in Malayo-Polynesian languages. When there is another liquid (/l/ or /r/) present in the stem, the rhotic of the /-ar-/ infix interacts with this liquid in a complex manner that involves both assimilation and dissimilation (Robins 1959, Cohn 1992, Holton 1995, Suzuki 1998, 1999, Curtin 2001).

Firstly, when followed by another /r/, the infixal /r/ dissimilates to [l]; that is, we see /r…r/ → [l…r]. The forms in (60a) illustrate the basic infixation pattern, whereas the dissimilation is shown in (60b). Syllable boundaries are indicated, for reasons that will become clear below. The infix portion of each plural form is underlined, and in (60b) the interacting liquids are shown in boldface.

(60) Liquid dissimilation in Sundanese distributive /-ar-/ (data from Cohn 1992)

	Singular	*Plural*	
a.	ku.sut	k-<u>a.r</u>-u.sut	'messy'
	po.ho	p-<u>a.r</u>-o.ho	'forget'
	di-vi.su.a.li.sa.si-kɨn	di-v-<u>a.r</u>-i.su.a.li.sa.si-kɨn	'visualized'

[47] Likewise, the analysis of stem-controlled vowel harmony by Baković (2000) relies on symmetric AGREE[F] constraints, which for practical purposes can largely be equated with IDENT[F]-CC constraints evaluating symmetric C↔C correspondence. The main difference is that CC correspondence is triggered by similarity and/or proximity, whereas the 'correspondence' relation evaluated by AGREE[F] is a consequence of (articulatory) adjacency.

b.	pər.ce.ka	p-<u>a.**l**</u>-ə**r**.ce.ka	'handsome'
	com.brek	c-<u>a.**l**</u>-om.b**r**ek	'cold'
	biŋ.har	b-<u>a.**l**</u>-iŋ.ha**r**	'rich'
	ŋum.ba.ra	ŋ-<u>a.**l**</u>-um.ba.**r**a	'go abroad'
	si.du.ru	s-<u>a.**l**</u>-i.du.**r**u	'sit by a fire'

Secondly, an exception to (60b) is that the dissimilation /r…r/ → [l…r] does not apply if the two liquids constitute (non-complex) onsets of adjacent syllables, as the two examples in (61a) show. If the onsets are further apart, dissimilation is not blocked, as in the last two examples in (60b): [ŋ-<u>a.**l**</u>-um.ba.**r**a], [s-<u>a.**l**</u>-i.du.**r**u]. Moreover, the /r/ of the infix likewise fails to dissimilate from a preceding stem-initial rhotic, as shown in (61b). This can possibly be interpreted as being due to the same inhibitory adjacent-syllable-onset effect as the cases in (61a).

(61) Sundanese: no dissimilation with adjacent-syllable onsets (Cohn 1992)

	Singular	*Plural/Distrib.*		
a.	cu.ri.ga	c-<u>a.**r**</u>-u.**r**i.ga	'suspicious'	(*c-<u>a.**l**</u>-u.**r**i.ga)
	di-ki.rim	di-k-<u>a.**r**</u>-i.**r**im	'sent (passive)'	(*di.-k-<u>a.**l**</u>-i.**r**im)
b.	rɨ.wat	**r**-<u>a.**r**</u>-ɨ.wat	'startled'	(***r**-<u>a.**l**</u>-ɨ.wat, ***l**-<u>a.**r**</u>-ɨ.wat)
	ra.hɨt	**r**-<u>a.**r**</u>-a.hɨt	'wounded'	(***r**-<u>a.**l**</u>-a.hɨt, ***l**-<u>a.**r**</u>-a.hɨt)

This summarizes the *dissimilatory* behavior of /-ar-/. More importantly, and as already discussed in §2.4.5, the /r/ of the infix also *assimilates* to a stem-initial /l/, as shown in (62a). By contrast, a stem-internal /l/ does not trigger assimilation, regardless of its status as onset (62b) or coda (62c).

(62) Sundanese: liquid assimilation to stem-initial /l/ (Cohn 1992)

	Singular	*Plural/Distrib.*		
a.	lɨ.tik	**l**-<u>a.**l**</u>-ɨ.tik	'little'	
	lə.ga	**l**-<u>a.**l**</u>-ə.ga	'wide'	
b.	gɨ.lis	g-<u>a.**r**</u>-ɨ.**l**is	'beautiful'	(*g-<u>a.**l**</u>-ɨ.**l**is)
	ŋu.li.at	ŋ-<u>a.**r**</u>-u.**l**i.at	'stretch'	(*ŋ-<u>a.**l**</u>-u.**l**i.at)
c.	gə.tol	g-<u>a.**r**</u>-ə.to**l**	'diligent'	(*g-<u>a.**l**</u>-ə.to**l**)
	ma.hal	m-<u>a.**r**</u>-a.ha**l**	'expensive'	(*m-<u>a.**l**</u>-a.ha**l**)

It is tempting to draw a direct parallel between the liquid assimilation in (62a) and the dissimilation-blocking pattern in (61), at least as regards stem-initial /r/ as in (61b). In both cases the interacting consonants are onsets of adjacent syllables, and in both cases the result is agreement in [±lateral]. The assimilatory effect is directly evident in (62a), but serves to block—that is, override—dissimilation in (61a–b).

It is a well-known fact that segments that share the same syllable position (and, in general, a similar phonotactic environment) are far more likely to interact with one another in phonological speech errors (slips of the tongue; see chapter 6 for extensive references). Word-initial consonants typically interact with other word-initial consonants, onset consonants interact with other onset consonants rather than with coda consonants, and so forth. Given the general claim made here that consonant harmony has its source in the domain of speech planning—that is, phonological encoding for speech production—it is not unreasonable to suggest that in Sundanese, there is a high-ranked demand for correspondence between liquids that are not merely in adjacent syllables (that is, 'transvocalic' liquid sequences) but occupy the same constituent/position within their respective syllables. Here this will be treated in terms of the combined effects of CORR-[lateral]$_{C\text{-}v\text{-}C}$ and a separate constraint SROLE-CC, which demands that CC-correspondents have identical syllabic roles (Rose & Walker 2004; S(T)ROLE is suggested as a constraint on Base-Reduplicant correspondence by McCarthy & Prince 1993 and is an important element in Gafos' 1998 analysis of a-templatic reduplication).[48] Given a ranking SROLE-CC >> CORR-[lateral]$_{C\text{-}v\text{-}C}$, a correspondence relation will be established in the sequences […**r**V.**r**V…], […**l**V.**l**V…], […**r**V.**l**V…], […**l**V.**r**V…], but the liquid pairs in sequences like […**l**V**r**.CV…] or […**l**V.CV.**r**V…] will not stand in correspondence, as they are either too far apart (separated by more than a vowel) or occupy distinct syllabic roles (onset vs. coda).

When combined with $^{\rightarrow}$IDENT[±lat]-CC, these constraints can account for the dissimilation blocking. Let us assume, with Suzuki (1999), that rhotic dissimilation is due to an OCP constraint *r…r that disallows the co-occurrence of rhotics at any distance.[49] If *r…r is ranked *lower* than the onset-agreement constraints, the blocking effect is achieved. This is illustrated in (63) and (64). For simplicity, the targeted nature of $^{\rightarrow}$IDENT[±lat]-CC is suppressed, and constraint evaluation proceeds in the usual fashion; this has no bearing on the outcome of the derivations. In the case of (63) /-ar-/ + /pərceka/ 'handsome', the two liquids (rhotics) do not occupy identical syllabic roles. Though CORR-[lat]$_{C\text{-}v\text{-}C}$ does call for a correspondence relation between the two, this is overridden by undominated SROLE-CC. With no correspondence pair to evaluate, IDENT[±lat]-CC is satisfied vacuously regardless of whether or not the liquids agree in [±lateral]. The result is dissimilation to [p-<u>a.**l**</u>-ə**r**.ce.ka], as in

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[48] Instead of adopting an SROLE constraint, the analysis of Sundanese in Hansson (2001b) posited a somewhat more parochial CORR-[lateral]$_{Ons(\sigma1\text{-}\sigma2)}$, building the onset requirement directly into the CORR-C⇔C constraint.

[49] Suzuki's actual formulation of this constraint is *[rhotic]…[rhotic], with [rhotic] being construed as a value for the feature [LIQUID] (cf. Walsh Dickey 1997); in this context, the difference is negligible. In Suzuki's analysis, the single constraint IDENT$\sigma_1\sigma_2$(rhotic)$_{ONS}$, which requires that 'adjacent syllables have identical onset rhotics', is the near-equivalent of the combined effects of $^{\rightarrow}$IDENT[±lateral]-CC with SROLE-CC >> CORR-[lateral]$_{C\text{-}v\text{-}C}$ in the present analysis.

(63c).[50] Note that the alternative *[p-<u>a.**r**</u>-ə**l**.ce.ka], with the *stem* liquid undergoing dissimilation, is not considered here. It is easily ruled out by IDENT[±lateral]-SA, ensuring that affix liquids always yield to stem liquids (stem control, essentially).

The derivation in (64) for /-ar-/ + /siduru/ 'sit by a fire' → [s-<u>a.**l**</u>-i.du.**r**u] is entirely analogous except in that here, the two (onset) liquids are too far apart for CORR-[lat]$_{C\text{-}v\text{-}C}$ to require that they stand in correspondence in the first place.

(63) Sundanese: no blocking of dissimilation (different syllabic roles)

/ar-, pərceka/	ID[±lat]-CC	SROLE-CC	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO
a. p-a.r_x-ər_y.ce.ka			*	*!	
b. p-a.r_x-ər_x.ce.ka		*!		*	
c. ☞ p-a.l_x-ər_y.ce.ka			*		*
d. p-a.l_x-ər_x.ce.ka	*!	*			*

(64) Sundanese: no blocking of dissimilation (liquids too far apart)

/ar-, siduru/	ID[±lat]-CC	SROLE-CC	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO
a. s-a.r_x-i.du.r_yu				*!	
b. s-a.r_x-i.du.r_xu				*!	
c. ☞ s-a.l_x-i.du.r_yu					*
d. s-a.l_x-i.du.r_xu	*!				*

In the case of /-ar-/ + /curiga/ 'suspicious' → [c-<u>a.**r**</u>-u.**r**i.ga] (61a), the derivation of which is shown in (65), the two rhotics do constitute onsets of adjacent syllables. Hence CORR-[lat]$_{C\text{-}v\text{-}C}$ does require (unhindered by SROLE-CC) that they enter into a CC correspondence relation, preferring (65b) and (65d) over (65a) and (65c). With a correspondence relation in place, IDENT[±lat]-CC prefers 'harmonic' (65b) over 'disharmonic' (65d). This prevents the lower-ranked dissimilation constraint *r…r from having any effect; in other words, dissimilation is *blocked*.

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[50] Strictly speaking →IDENT[lat]-CC, being a targeted constraint, asserts only that (63d) is worse than (63b): $b \succ d$. Since *r…r adds to this the orderings $d \succ a$ and $c \succ b$ (as well as $c \succ a$), the resulting cumulative ordering is $c \succ b \succ d \succ a$. Candidate (63c) thus emerges as optimal, exactly as in the simplified tableau shown here.

(65) Sundanese: dissimilation blocked for adjacent-syllable onset liquids

/ar-, curiga/	ID[±lat]-CC	SROLE-CC	CORR-[lat]$_{\text{C-v-C}}$	*r…r	ID[±lat]-IO
a. c-a.r_x-u.r_yi.ga			*!	*	
b. ☞ c-a.r_x-u.r_xi.ga				*	
c. c-a.l_x-u.r_yi.ga			*!		*
d. c-a.l_x-u.r_xi.ga	*!				*

Though it successfully accounts for dissimilation blocking, the above analysis has one important drawback, in that it erroneously predicts that an adjacent-syllable onset [l] will *trigger assimilation* in the /-ar-/ infix. For example, we expect that /-ar-/ + /ŋuliat/ → *[ŋ-a.**l**-u.**l**i.at] instead of correct [ŋ-a.**r**-u.**l**i.at]. At first glance, we might take this to indicate that it is only $^{(\rightarrow)}$IDENT[–lat]-CC that is high-ranked in Sundanese, not its $^{(\rightarrow)}$IDENT[+lat]-CC counterpart. Given that correspondence has been construed as a unidirectional $C_1 \leftarrow C_2$ relation, the constraint IDENT[–lat]-CC will prefer [r_x…r_x] sequences over [l_x…r_x], but will have nothing to say about the [l_x…l_x] vs. [r_x…l_x] comparison (as the C_2 member of these liquid pairs is not [–lateral]). This is largely equivalent to the analysis proposed by Suzuki (1999), whose onset-identity constraint refers to rhotics specifically, rather than liquids in general.

However, recall that the /r/ of the /-ar-/ infix does in fact assimilate to an adjacent-syllable onset [l] in one context, namely when that [l] is stem-initial, as shown in (62a) above (/-ar-/ + /ləga/ → [**l**-a.**l**-ə.ga], etc.). Likewise, a stem-initial [r] blocks dissimilation just as a stem-internal (adjacent-syllable onset) [r] does. If the same kind of inter-onset correspondence is behind both the dissimilation-blocking effects and the assimilation effects, then the following asymmetry must be explained:

(66) Sundanese: asymmetry of between-onset liquid agreement effects

a. If the triggering (stem) liquid *precedes* the target (infix) liquid:
$C_1 \leftarrow C_2$ agreement both in [–lateral] (dissimilation blocking) and in [+lateral] (assimilation)

b. If the triggering (stem) liquid *follows* the target (infix) liquid:
$C_1 \leftarrow C_2$ agreement in [–lateral] (dissimilation blocking) only.

In all cases, the agreement effects obey stem control, in that the trigger is a stem liquid and the target an affix liquid. But since we are dealing with an *infix* rather than a prefix or suffix, the stem is, in effect, on both sides of the affix. In this situation, stem control ought to result in perseveratory harmony (assimilation to a stem-initial consonant) and anticipatory harmony (assimilation to a stem-internal consonant). This is not a problem in the [–lateral] case, as anticipatory [–lateral] agreement, manifested as dissimilation blocking, shows both directionality patterns: dissimilation of [r…r] sequences is blocked for [r_{stem}…r_{affix}] and [r_{affix}…r_{stem}] alike.

The [+lateral] case, on the other hand, presents a serious problem. There is no way to rank IDENT[+lat]-CC such that it will successfully produce perseveratory (stem-to-affix) harmony (in the guise of dissimilation blocking) in [r_{stem}…l_{affix}] sequences *without* also erroneously yielding anticipatory (stem-to-affix) harmony in [r_{affix}…l_{stem}] sequences. If anything, the reverse would be expected, due to the inherent directionality of the $C_1 \leftarrow C_2$ relation. A hypothetical 'Pseudo-Sundanese' system, with anticipatory [+lateral] harmony (as in, e.g., /-ar-/ + /ŋuliat/ → [ŋ-a.**l**-u.**l**i.at]) but without perseveratory [+lateral] harmony (/-ar-/ + /ləga/ → [**l**-a.**r**-ə.ga]), would result from the ranking IDENT[±lat]-SA >> $^{(\rightarrow)}$IDENT[+lat]-CC >> IDENT[±lat]-IO >> $^{(\rightarrow)}$IDENT[–lat]-CC. But there is no way to privilege perseveratory directionality over anticipatory directionality in the model developed here.[51]

A possible solution is to view the relationship between a stem-initial liquid and the infixal /r/ as being of different in kind from the relationship between infixal /r/ and a following (stem-internal) liquid. For example, Suzuki (1999) proposes that the /-ar-/ infix is a *reduplicative* morpheme, /-ar^{RED}-/ (see Gafos 1998; cf. §4.1.3).[52] Assuming that Base-Reduplicant correspondence constraints such as L-ANCHOR-BR ensure that the infixal /r/ will be a (BR) correspondent of a stem-initial liquid, the agreement effect can be captured by means of IDENT[±lat]-BR. We now have two freely rankable constraint types, operating along entirely independent dimensions of correspondence, {IDENT[+lat]-BR, IDENT[–lat]-BR } on the one hand and {$^{(\rightarrow)}$IDENT[+lat]-CC, $^{(\rightarrow)}$IDENT[–lat]-CC} on the other. The former two constraints penalize non-identical *word-initial* sequences [l-a.rV.C…], [r-a.l-V.C…]; if high-ranked, they can thus account for assimilation in /l-ar-VC…/ → [**l**-a.**l**-V.C…] as well as dissimilation blocking in /r-ar-VC…/ (↛ *[**r**-a.**l**-V.C…]). The constraint $^{(\rightarrow)}$IDENT[–lat]-CC, which effectively penalizes all […lV.rV…] sequences, serves to block dissimilation in /C-ar-V.rV…/ contexts (↛ *[C-a.**l**-V.**r**V…]). Its counterpart $^{(\rightarrow)}$IDENT[+lat]-CC low, which

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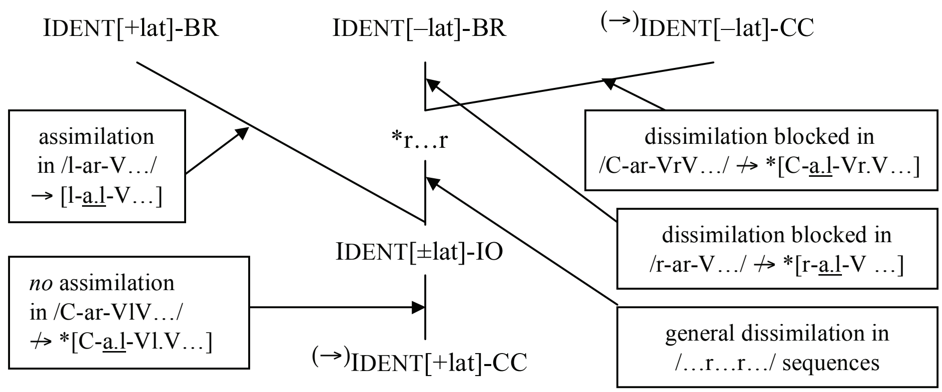
[51] McCarthy (2003a) proposes a rather different approach to the paradox in (66) than the one laid out below. He views the fact that output […rV.lV…] sequences are avoided 'passively', through blocking of rhotic dissimilation in [rV.rV…] sequences, but not 'actively' (through assimilation in […rV.lV…] sequences), as a 'grandfather effect': […rV.lV…] are permissible as long as both liquids are faithful, but not if the sequence is being produced by an unfaithful IO mapping (such as by active dissimilation of /r…r/). In McCarthy's analysis, the relevant constraint *rVlV, which is largely equivalent to our $^{(\rightarrow)}$IDENT[+lateral]-CC (with the added contributions of CORR-$[lat]_{C\text{-}v\text{-}C}$ and SROLE-CC), is split into an 'old' and a 'new' version; only the latter is ranked above OCP(r) constraint (which is equivalent to our *r…r).

[52] Suzuki represents the morpheme as /-aL^{RED}-/, where /L/ represents an underspecified liquid. The default realization of this segment as [r], in cases where dissimilation or correspondence constraints have no effect, results from the markedness constraint *l. For the purpose of the issues at hand, the two characterizations do not differ in their predictions.

penalizes […rV.lV…] sequences and therefore threatens to trigger assimilation in cases like /C-ar-V.lV…/ (↛ *[C-a.**l**-V.**l**V…]) must be ranked below the OCP constraint *r…r.

By dividing the labor of penalizing […rV.lV…] sequences between $^{(\rightarrow)}$IDENT[+lat]-CC (which bans *all* such sequences) and IDENT[–lat]-BR (which bans word-initial [r-a.r-V…] sequences only), the ranking paradox can thus be resolved. The required ranking is shown in the Hasse diagram in (67). (The additional ranking relations SROLE-CC >> CORR-[lat]$_{C\text{-}v\text{-}C}$ >> *r…r have been omitted here.) For all intents and purposes, the analysis laid out in (67) copies the one proposed by Suzuki (1999), modulo the use of CC correspondence as the formal mechanism for long-distance assimilatory interactions among consonants.

(67) Crucial rankings for Sundanese liquid assimilation and dissimilation:



The effects of the constraint ranking in (67) is demonstrated in tableaux (68)–(71). The first two derivations demonstrate how $^{(\rightarrow)}$IDENT[–lat]-CC is able to block the dissimilatory effect of the constraint *r…r (68) without also forcing assimilation of the infixal /r/ to a following /l/ (69). As in previous tableaux, the targeted character of the IDENT[F]-CC constraints has been suppressed.

(68) Sundanese: blocked dissimilation from following rhotic (onset of adjacent syllable)

/-ar-, curiga/	ID[–lat]-CC	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO
a. c-a.r$_x$-u.r$_y$i.ga		*!	*	
b. ☞ c-a.r$_x$-u.r$_x$i.ga			*	
c. c-a.l$_x$-u.r$_y$i.ga		*!		*
d. c-a.l$_x$-u.r$_x$i.ga	*!			*

(69) Sundanese: no assimilation to lateral (onset of adjacent syllable)

/-ar-, ŋuliat/	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO	ID[+lat]-CC
a. ŋ-a.r$_x$-u.l$_y$i.at	*!			
b. ☞ ŋ-a.r$_x$-u.l$_x$i.at				*
c. ŋ-a.l$_x$-u.l$_y$i.at	*!		*	
d. ŋ-a.l$_x$-u.l$_x$i.at			*!	

Recall that, due to the directionally asymmetric nature of the C$_1$←C$_2$ correspondence relation, $^{(\rightarrow)}$IDENT[–lat]-CC bans […l$_x$V.r$_x$V…] sequences exclusively, whereas $^{(\rightarrow)}$IDENT[+lat]-CC penalizes only […r$_x$V.l$_x$V…] sequences. The undominated ranking of the former, and the low ranking of the latter (below faithfulness to underlying [±lateral] values) is what captures the effects in (68)–(69).

The derivations in (70) and (71) show what happens when BR correspondence becomes relevant, namely when one of the interacting liquids is stem-initial. In the tableaux, BR correspondence is indicated with subscript Greek letters ('α') whereas CC correspondence is as before shown with subscript 'x' and 'y'. Note that the stem-initial and infixal liquids are linked *simultaneously* by CC correspondence (due to being adjacent-syllable onsets) and BR correspondence (due to the infix being a reduplicative morpheme, /-ar^{RED}/).

(70) Sundanese: blocked dissimilation from preceding (stem-initial) rhotic

/-ar-, rɨwat/	ID[–lat]-BR	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO	ID[+lat]-CC
a. r$_{x,\alpha}$-a.r$_{y,\alpha}$-ɨ.wat		*!	*		
b. ☞ r$_{x,\alpha}$-a.r$_{x,\alpha}$-ɨ.wat			*		
c. r$_{x,\alpha}$-a.l$_{y,\alpha}$-ɨ.wat	*!	*		*	
d. r$_{x,\alpha}$-a.l$_{x,\alpha}$-ɨ.wat	*!			*	*

(71) Sundanese: assimilation to preceding (stem-initial) lateral

/-ar-, ləga/	ID[+lat]-BR	CORR-[lat]$_{C\text{-}v\text{-}C}$	*r…r	ID[±lat]-IO
a. l$_{x,\alpha}$-a.r$_{y,\alpha}$-ə.ga	*!	*		
b. l$_{x,\alpha}$-a.r$_{x,\alpha}$-ə.ga	*!			
c. l$_{x,\alpha}$-a.l$_{y,\alpha}$-ə.ga		*!		*
d. ☞ l$_{x,\alpha}$-a.l$_{x,\alpha}$-ə.ga				*

The analysis of the interaction with stem-initial consonants as Base-Reduplicant correspondence may seem ad hoc, but it is motivated for independent reasons. In Sundanese, as in many related languages, initial CV-reduplication is rampant, resulting in surface forms with the structure [C_iV-C_iV…] just as in (70)-(71). Furthermore, identical consonants are generally banned from co-occurring in words of Sundanese (especially in adjacent syllables) *except* in word-initial /C_iVC_iV…/ sequences—regardless of whether or not the word in question can be analyzed as morphologically reduplicated or not. The behavior of the /r/ of the infix /-ar-/ parallels these general phonotactic patterns in a way that is unlikely to be accidental.

Another case which at first glance seems to pose a problem with respect to directionality is the 'canonical' nasal consonant harmony (NCH) pattern found in many Bantu languages (see §2.4.4 above). Recall that in canonical Bantu NCH, a (voiced) oral consonant in a suffix assimilates to a nasal in the preceding stem, as in Yaka /-tsúm-idi/ → [-tsúm-ini] 'sew (perf.)' (Hyman 1995). Such interactions are easily dealt with as a matter of stem control. Root-internally, however, stem control is irrelevant, and directionality of assimilation must therefore be dependent on other factors. As Hyman (1995) shows for Yaka, the distributional pattern is quite general, and goes beyond mere suffix alternations: 'voiced oral consonants may not occur in stems which have an earlier (full) nasal'.[53] In other words, [+nasal]…[–nasal] sequences of voiced consonants, such as [m…d], [n…w], [ɲ…l], etc., are not allowed, even root-internally. By contrast, [–nasal]…[+nasal] sequences are permitted, both root-internally and in heteromorphemic contexts: [w…ɲ], [l…m], [b…n], and so forth. The generalization seems to be that canonical Bantu NCH follows a consistently perseveratory (progressive, left-to-right) directionality, independently of morphological constituency. This is further bolstered by diachronic evidence, which clearly shows that the sound change responsible for the synchronic pattern was due to progressive assimilation, even within roots (e.g., /min-/ 'swallow' < Proto-Bantu **mid-*). In short, explaining the perseveratory directionality in stem + suffix contexts (/-tsúm-idi/ → [-tsúm-ini]) as being due to stem control misses a much larger generalization. In short, canonical Bantu NCH seems to display an *absolute* perseveratory directionality; this would appear to be a problem for the analytical model proposed in this chapter, since that model relies on an anticipatory orientation being built into the $C_1 \leftarrow C_2$ correspondence relation. In what we have seen thus far, the only two directionality patterns possible are stem-controlled harmony (which will be manifested as perseveratory assimilation in suffixation contexts) and absolute *anticipatory* harmony.

For this reason, Hansson (2001b) took canonical Bantu NCH to be a serious challenge to the model, and went to considerable lengths to find a workaround that would allow it to be captured. As it turns out, however, the model is capable of generating absolute perseveratory directionality of exactly this kind, and does so quite effortlessly. The crucial property of Bantu NCH that allows for this is its 'single-value' (featurally asymmetric) character. Unlike absolute-directionality systems like Ineseño Chumash, where both values of the harmonic

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[53] In this context, 'stem' refers to a sequence of the root plus any number of derivational suffixes, so-called 'extensions' (applicative, reciprocal, causative and passive, etc.).

feature are capable of triggering assimilation, in Bantu languages it is only [+nasal] that gets 'copied' from one consonant to another, not [–nasal]. The kind of (hypothetical) consonant harmony system that the model would be truly incapable of capturing is the mirror image of Ineseño Chumash: a featurally *symmetric* ('double-value') system displaying absolute perseveratory directionality.

The ranking that produces the canonical Bantu NCH pattern is $\rightarrow$IDENT[–nas]-CC >> IDENT[+nas]-IO >> IDENT[–nas]-IO >> $\rightarrow$IDENT[+nas]-CC. Note that, given the inherent directionality of the $C_1 \leftarrow C_2$ relation, undominated $\rightarrow$IDENT[–nas]-CC specifically penalizes [+nasal]…[–nasal] sequences ([m…d], etc.), whereas $\rightarrow$IDENT[+nas]-CC, which penalizes only [–nasal]…[+nasal] sequences ([d…m]) is ranked too low to have any effect. Despite the fact that the undominated constraint $\rightarrow$IDENT[–nas]-CC asserts the preference [–nas]…[–nas] ≻ [+nas]…[–nas], the interaction between $\rightarrow$IDENT[–nas]-CC and IDENT[+nas]-IO makes [+nas]…[+nas] ([m…n]) emerge as the optimal output for a [+nas]…[–nas] input (/m…d/):

(73) Canonical Bantu NCH: perseveratory assimilation for [+nasal]…[–nasal] input

/mid-a/	$\rightarrow$ID[–nas]-CC	ID[+nas]-IO	ID[–nas]-IO	$\rightarrow$ID[+nas]-CC
a. $m_x id_x a$	b ≻ a			
b. $b_x id_x a$		(a ≻ b); c ≻ b		
c. ☞ $m_x in_x a$			{a, b} ≻ c	
d. $b_x in_x a$		{a, c} ≻ d	{a, b} ≻ d	c ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>	(a ≻ b); <u>c ≻ b</u>; <u>a ≻ d</u>; c ≻ d	(a ≻ c); (b ≻ c); a ≻ d; b ≻ d	c ≻ d
Cumulative harmonic ordering	b ≻ a	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)	

(73) Canonical Bantu NCH: no assimilation for [–nasal]…[+nasal] input

/dim-a/	→ID[–nas]-CC	ID[+nas]-IO	ID[–nas]-IO	→ID[+nas]-CC
a. ☞ $d_x im_x a$				(b ≻ a)
b. $n_x im_x a$			a ≻ b; (c ≻ b)	
c. $d_x ib_x a$		{a, b} ≻ c		
d. $n_x ib_x a$	c ≻ d	{a, b} ≻ d	{a, c} ≻ d	
Harmonic ordering by constraint	c ≻ d	a ≻ c; b ≻ c; a ≻ d; b ≻ d	a ≻ b; (c ≻ b); a ≻ d; c ≻ d	c ≻ d
Cumulative harmonic ordering	c ≻ d	{a, b} ≻ c ≻ d	☞**a** ≻ b ≻ c ≻ d	

Another case that displays an unusual directionality pattern, and which Hansson (2001b) took to be a serious challenge to the model proposed here, is related to the 'canonical' Bantu NCH phenomenon discussed above. This is the peculiar version of nasal consonant harmony in the Bantu language Tiene (Ellington 1977, Hyman & Inkelas 1997, Hyman 2006). As was described in detail in §2.4.4 above, the CVCVC verb-stem template in Tiene requires agreement in nasality between C_2 and C_3 of the template. In some cases, C_3 belongs to a derivational suffix (e.g., stative /-Vk/), but sometimes it is C_2 that is affixal, belonging instead to a derivational *infix* (e.g., applicative /-lV-/ or causative /-sV-/).

As the forms in (74) show, a stem-final nasal triggers nasalization in a derivational affix. In (74a) the directionality is perseveratory (from stem to suffix), whereas in (74b) it is anticipatory (from stem to infix). In the derived forms on the right, the relevant derivational affix (suffix or infix) is underlined, and the CVCVC template is enclosed in curly brackets { }.

(74) Tiene: nasal agreement in C_2 and C_3 of CVCVC template (Hyman 2006)

a. Nasalization in suffixed stative /-Vk-/

jaːt-a	'split'	{jat-ak}-a	'be split'
ból-a	'break'	{ból-ek}-ɛ	'be broken'
vwuɲ-a	'mix'	{vwu**ɲ**-e**ŋ**}-ɛ	'be mixed'
sɔ́n-ɔ	'write'	{sɔ́**n**-ɔ**ŋ**}-ɔ	'be written'

b. Nasalization in infixed applicative /-lV-/

bák-a	'reach'	{bá-la-k}-a	'reach for'
jɔb-ɔ	'bathe'	{jɔ-lɔ-b}-ɔ	'bathe for'
dum-a	'run fast'	{du-**n**e-**m**}-ɛ	'run fast for'
lɔŋ-ɔ	'load'	{lɔ-**n**ɔ-**ŋ**}-ɔ	'load for'

Both directionalities in (74) can be construed as manifestations of stem control, since the affix consistently yields to the stem. But another possibility is to take the harmony as being a 'single-value' system, with [+nasal] as the active (or 'dominant') feature value. This is, in essence, how canonical Bantu nasal consonant harmony was analyzed in (72)–(73) above, where the ranking IDENT[+nas]-IO >> IDENT[–nas]-IO encodes the primacy of (underlying) [+nasal] specifications over [–nasal] ones, allowing harmony to proceed by nasalization only, never denasalization.

Where Tiene becomes potentially problematic is in the additional facts shown in (75). When the affix contains an /s/, as in the causative infix /-sV-/, the result is not nasalization of the affixal /s/ but *denasalization* of the stem nasal, as in (75b) examples. The explanation for this presumably lies in /s/ being inherently non-nasalizable in Tiene: [s̃] or [z̃] are impermissible segments, and/or faithfulness to features such as [±strident] is high-ranked enough to prevent any other [+nasal] output realizations of an input /s/.

(75) Tiene: denasalization with infixed causative /-sV-/ (Hyman 2006):

a.	lab-a	'walk'	{la-sa-b}-a	'cause to walk'
	kuk-a	'be sufficient'	{ku-si-k}-ɛ	'make sufficient'
b.	tóm-a	'send'	{tó-**s**e-**b**}-ɛ	'cause to send'
	dím-a	'get extinguished'	{dí-**s**e-**b**}-ɛ	'extinguish'
	suɔm-ɔ	'borrow'	{sɔ-**s**ɔ-**b**]-ɔ	'lend'

The apparent problem with the denasalization effect in (75) is twofold. Firstly, the feature value being 'transmitted' is [–nasal] rather than [+nasal]. This seems to contradict what was said above about [+nasal] being the sole active or dominant feature in the harmony. And stem control is clearly not at play in this instance, since a stem consonant is assimilating to an affix consonant, not vice versa. Secondly, the directionality is perseveratory (left-to-right) here: /s…m/ → [s…b]. If the only possible sources of perseveratory assimilation are stem control (as in §4.3.2 above) or the dominant status of the [±F] value being transmitted (as in (72)–(73) above), then the directionality observed in (75b) would seem an intractable problem.

As it turns out, however, the Tiene pattern is easily accommodated. All that is required is a ban against nasalized fricatives (*NASFRIC; cf. Walker 2000b) outranking the faithfulness constraint IDENT[+nasal]-IO. (Note that this ranking is independently needed in order to account for the absence of nasalized fricatives from the Tiene consonant inventory in the first place.) In terms of the overall ranking for the general nasal consonant harmony effect in (74), we need to assume that both $^{\rightarrow}$IDENT[–nasal]-CC and $^{\rightarrow}$IDENT[+nasal]-CC outrank faithfulness to underlying [±nasal] specifications. This is because agreement is enforced both in [+nasal]…[–nasal] sequences (74a) and [–nasal]…[+nasal] ones (74b). Both are harmonized to [+nasal]…[+nasal], attesting to the dominant status of [+nasal]. This means that the ranking among IO faithfulness constraints is IDENT[+nas]-IO >> IDENT[–nas]-IO, just as in the canonical Bantu NCH cases.

The tableaux in (76) and (77) show how this ranking correctly produces anticipatory or perseveratory assimilation depending on which side the [+nasal] trigger is on. Since both of the $\rightarrow$IDENT[F]-CC constraints are undominated, they are conflated into a single constraint in the tableaux for simplicity.

(76) Tiene: anticipatory assimilation (stem-to-infix) in [–nas]…[+nas] context

/lɔŋ, -lV-/	$\rightarrow$IDENT[nas]-CC	IDENT[+nas]-IO	IDENT[–nas]-IO
a. lɔ-l_xɔ-$ŋ_x$-	b ≻ a		
b. ☞ lɔ-n_xɔ-$ŋ_x$-			({a, c} ≻ b)
c. lɔ-l_xɔ-k_x-		{a, b} ≻ c	
d. lɔ-n_xɔ-k_x-	c ≻ d	{a, b} ≻ d	{a, c} ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>; <u>c ≻ d</u>	<u>a ≻ c</u>; b ≻ c; a ≻ d; c ≻ d	(a ≻ b); (c ≻ b); a ≻ d; c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d	(b ≻ a ≻ c ≻ d)

(77) Tiene: perseveratory assimilation (stem-to-suffix) in [+nas]…[–nas] context

/sɔ́n-Vk-/	$\rightarrow$IDENT[nas]-CC	IDENT[+nas]-IO	IDENT[–nas]-IO
a. sɔ́n_x-ɔk_x-	b ≻ a		
b. sɔ́l_x-ɔk_x-		(a ≻ b); c ≻ b	
c. ☞ sɔ́n_x-ɔ$ŋ_x$-			({a, b} ≻ c)
d. sɔ́l_x-ɔ$ŋ_x$-	c ≻ d	{a, c} ≻ d	{a, b} ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>; <u>c ≻ d</u>	(a ≻ b); <u>c ≻ b</u>; <u>a ≻ d</u>; c ≻ d	(a ≻ c); (b ≻ c); a ≻ d; b ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

In order to correctly capture the denasalization cases in (75b), all we need to assume is that *NASFRIC is ranked *between* $\rightarrow$IDENT[+nasal]-CC and IDENT[+nas]-IO. This is shown in (78). (Since, as we have seen above, IDENT[–nas]-IO is ranked too low to have any impact on output selection, it has been left out of this tableau.) To preclude other conceivable mappings involving nasalization of the input /s/, such as /dím, -sV-/ → *[dí-**n**$_x$e-**m**$_x$-] (with /s/ → [n]), a constraint like IDENT[+strident]-IO would also need to be ranked between →IDENT[nas]-CC and IDENT[+nas]-IO.[54]

(78) Tiene: perseveratory denasalization (infix-to-stem) triggered by [s]

/dím, -sV-/	→IDENT[nas]-CC	*NASFRIC	IDENT[+nas]-IO
a. dí-s$_x$e-m$_x$-	b ≻ a		
b. dí-s̃$_x$e-m$_x$-		(a ≻ b); c ≻ b	
c. ☞ dí-s$_x$e-b$_x$-			({a, b} ≻ c)
d. dí-s̃$_x$e-b$_x$-	c ≻ d	{a, c} ≻ d	{a, b} ≻ d
Harmonic ordering by constraint	$\underline{b \succ a}$; $\underline{c \succ d}$	a ≻ b; $\underline{c \succ b}$; $\underline{a \succ d}$; c ≻ d	(a ≻ c); (b ≻ c); a ≻ d; c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

In sum, we can conclude (*contra* Hansson 2001b) that the cases of nasal consonant harmony in Bantu languages do not constitute problems for the analysis presented here with respect to their directionality patterns. Both the 'canonical' pattern (Yaka, Kongo, Lamba, etc.) and the highly unusual pattern found in Tiene, are captured relatively easily, as long as we adopt distinct [+F] and [–F] versions of IDENT[F]-IO faithfulness constraints.

With respect to directionality patterns, the only serious challenge to the present model is thus the interplay of liquid dissimilation and assimilation in Sundanese. As we saw above, however, this case may well involve (covert) Base-Reduplicant correspondence (as proposed by Suzuki 1999, drawing on Gafos 1998) in addition to agreement by CC correspondence. When analyzed in this way, even Sundanese ceases to be a problem case.

[54] Needless to say, there are many complications of the Tiene system that I do not attempt to handle here. One is the limitation of nasal agreement (and correspondence?) to the C_2-C_3 pair in the CVCVC template; that is, the failure of C_1 to trigger agreement (in an infixal C_2). Another issue is the place-of-articulation sequencing restrictions that govern the infixing vs. suffixing placement of individual affixes (see Hyman & Inkelas 1997, Hyman 2006).

5. ANALYZING CONSONANT HARMONY: BEYOND THE BASICS

The previous chapter laid out the fundamental aspects of the analysis of consonant harmony as agreement by correspondence (ABC) and demonstrated how the two basic directionality patterns (stem control and anticipatory harmony) arise given the appropriate constraint rankings. This chapter further develops that framework of analysis, showing how it is capable of handling patterns that go beyond these basic scenarios. Of particular interest is the interplay between harmony and independent phonotactic restrictions, the latter reflecting contextual markedness constraints. Such interplay with markedness-related effects is the main focus of this chapter.

The chapter is organized as follows. Section §5.1 shows how interaction with phonotactic demands can result in intricate patterns of blocking and overrides. Section §5.2 addresses the common state of affairs where harmony is enforced exclusively as a (static) morpheme-internal co-occurrence restriction. Finally, section §5.3 outlines some issues and potential problems that are left to future research.

5.1. Interaction with Markedness: Overrides and Blocking Effects

We saw in §4.3 how the targeted-constraint analysis of consonant harmony generates the attested directionality patterns: stem control and morphology-insensitive anticipatory (regressive, right-to-left) harmony. The differences between these two major types lie in how the harmony-triggering →IDENT[F]-CC constraints interact with faithfulness constraints, specifically IDENT[F]-IO and IDENT[F]-SA. But what about markedness constraints, such as those that define phonotactic well-formedness? Do these freely interact with the →IDENT[F]-CC constraints (and/or the CORR-C↔C constraints)? If so, what patterns does this predict, and are those predictions borne out in the cross-linguistic typology of consonant harmony? These are some of the questions that will be dealt with in this section.

First, let us consider some basic aspects of factorial typology as regards phonotactics and markedness. Phonotactic generalizations generally arise from the interaction of context-sensitive markedness constraints on the one hand with context-free markedness constraints and (input-output) faithfulness constraints on the other (see Kager 1999, McCarthy 2002a). As a schematic example, let us assume a pair of segments X and Y, which differ solely in feature [±F]. For example, X vs. Y might represent oral [ɑ] vs. nasal [ɑ̃], or voiceless [k] vs. voiced [g]. The relevant constraints would then be the following:

(1) Constraints relevant for deriving contextual effects

a. Faithfulness: IDENT[F]-IO
Input [±F] specifications must be preserved in the output; this prohibits /X/ → [Y] and /Y/ → [X], thus allowing a surface [X] : [Y] contrast.

b. Context-sensitive markedness: *X / A__B
[X] is not allowed in the context A__B (e.g. an oral vowel is not allowed before a nasal, a voiceless obstruent is not allowed in intervocalic position).

c. Context-free markedness: *Y
[Y] is not allowed in any context (e.g. no nasal vowels, no voiced obstruents).

These constraint types interact to affect the relative distribution of [X] and [Y] in the output. The least interesting situation arises when IDENT[F]-IO is top-ranked; regardless of how the markedness constraints are ranked relative to each other, the result will be that an [X] : [Y] contrast is free to occur (i.e. is preserved) in all contexts. In such situations, the markedness constraints are ranked so low as to be entirely irrelevant, and they are thus also unable to interact with harmony-triggering →IDENT[F]-CC constraints in any interesting way.

More relevant are rankings in which faithfulness (1a) is outranked by one or both of the markedness constraints in (1b–c). Moreover, note that if it is to have any effect at all, context-sensitive *X / A__B must outrank context-free *Y in order to have any effect. If *Y >> *X / A__B, then surface [Y] will never occur at all, even in the A__B environment. Under these circumstances, again, there will be no potential for interesting interactions between the phonotactic distribution of [X] vs. [Y] and consonant harmony. The ranking *X / A__B >> *Y, by contrast, ensures that /X/ and /Y/ will neutralize to [Y] in the specific context A__B. In short, the ranking schemata we are interested in are the ones shown in (2).

(2) Relevant ranking schemata for contextual markedness effects

a. Allophonic distribution of [X] vs. [Y]
*X / A__B >> *Y >> IDENT[F]-IO

b. Contextual neutralization of /X/ vs. /Y/ contrast (to [Y])
*X / A__B >> IDENT[F]-IO >> *Y

In each of the rankings in (2), the two higher-ranked constraints jointly determine the surface distribution of [X] and [Y]. In (2a), [X] and [Y] are in complementary distribution: [X] is found in all environments except A__B, where [Y] occurs instead. In (2b), however, [X] and [Y] *contrast* in all environments except A__B, where the contrast is neutralized to [Y].

We now return to the question of how markedness constraints such as those involved in (2) can interact with the constraints enforcing consonant harmony. Specifically, the issue of concern is how →IDENT[F]-CC may be interleaved with the rankings in (2). Given that [X] and [Y] differ in [±F], this constraint has the potential of interfering with the general distribution patterns generated by (2a) and (2b). Likewise, the constraints in (2) can interfere with the harmony pattern that →IDENT[F]-CC would otherwise give rise to. This is true in particular of the context-sensitive constraint type *X / A__B which is top-ranked in both ranking scenarios in (2). Setting aside the (2a) vs. (2b) distinction for the moment, the two fundamental rankings we need to consider are the ones shown in (3).

(3) Interplay of markedness with consonant harmony: possible scenarios

a. *X / A__B >> **→IDENT[F]-CC** >> {*Y, IDENT[F]-IO}

b. **→IDENT[F]-CC** >> *X / A__B >> {*Y, IDENT[F]-IO}

We need not consider a ranking like *X / A__B >> *Y >> →IDENT[F]-CC, because here the harmony-driving constraint is ranked too low to have any effect; the same is true of the ranking *X / A__B >> IDENT[F]-IO >> →IDENT[F]-CC. In each of these cases, the two higher-ranked constraints exhaustively determine the surface distribution of [X] and [Y], and the constraint →IDENT[F]-CC is unable to affect that distribution in any way.

In fact, each of the two scenarios in (3) is attested in the typology of consonant harmony systems. The pattern resulting from (3a), where contextual markedness overrides harmony, is discussed in §5.1.1. In (3b) the interaction is more subtle; this scenario is discussed in §5.1.2. Finally, we also need to consider the effects that result from a markedness constraint being interleaved into the similarity-based hierarchy of CORR-C↔C constraints; this too is attested. Such interaction effects are covered in §5.1.3.

In the analyses developed below, context-sensitive markedness constraints are assumed to be *targeted constraints*, just as →IDENT[F]-CC itself is. A constraint of the type described here as *X / A__B thus targets [X] as a marked element given the particular context A__B (typically this is an environment in which the perceptual cues for the [X] vs. [Y] distinction are weak or impoverished). This is in accordance with the theory of targeted constraints as developed by Wilson (2000, 2001, 2003, 2006; see also Baković & Wilson 2000). Indeed, the strongest motivation for targeted constraints as such derives precisely from contextual markedness effects, specifically contextual neutralization. Although the targeted-constraint formalization of the *X / A__B constraint is not crucial for the (3a) scenario, it is of considerable importance in (3b), as we shall see in §5.1.2.

5.1.1. Scenario I: Contextual Markedness Overrides Harmony

When a context-sensitive markedness constraint outranks the harmony-driving constraint (*X / A__B >> →IDENT[F]-CC), consonant harmony will be prevented from producing [X] in the environment A__B. In other words, markedness *blocks* harmony from being enforced in precisely that context. For example, an input /Y…X/ sequence would generally be harmonized to [X…X] in the output, but in the special case /AYB…X/, the harmony is blocked from producing the output configuration [AXB…X], as this would violate the higher-ranked constraint *X / A__B. The clearest instance of blocking effects of this kind is Chumash sibilant harmony. The preliminary analysis of Ineseño sibilant harmony in §4.3.1 skirted around those details of the harmony patterns that have to do with blocking by markedness. Here we will see how that analysis can be augmented to account for these facts as well.

Many of the Chumashan languages display a so-called ‘pre-coronal effect’, whereby alveolar sibilants (/s/, /ts/, etc.) are realized differently before non-sibilant coronals like [t], [n] and [l] than otherwise. Sometimes the realization in precoronal contexts is described as *apico*-alveolar, as opposed to the normal *lamino*-alveolar articulation (Mithun 1998). In this case the difference appears to be a purely allophonic one, and as such, it should not interfere at all with the sibilant harmony system, which involves the alveolar (/s/, /ts/) vs. post-alveolar (/ʃ/, /tʃ/) contrast.

In at least some of the Chumashan languages, including Ineseño (as well as Ventureño; see Harrington 1974), it seems that the apicals resulting from this (allophonic) precoronal effect have merged with the postalveolars, giving rise to a synchronic pattern of contextual neutralization. As a result, the surface contrast between /s/ and /ʃ/ is suspended in the environment __{t, n, l}, where only [ʃ] is allowed (and analogously for /ts/ vs. /tʃ/, and so forth). The neutralization is illustrated for Ineseño in (4a). As the forms in (4b) show, the precoronal effect results in the blocking of right-to-left sibilant harmony. Note also that the postalveolar sibilant resulting from the precoronal effect will itself trigger harmony on any preceding sibilant; this aspect of Ineseño sibilant harmony will be further discussed below.

(4) Precoronal effect in Ineseño (data from Applegate 1972)

a. [+ant] → [–ant] in 3Subj prefix /s-/:

ʃtepuʔ	/s-tepuʔ/	‘he gambles’
ʃnit^{h}oj	/s-nit^{h}oj/	‘it is possible’
ʃlok’in	/s-lok’in/	‘he cuts it’

b. Precoronal effect blocks (and feeds!) sibilant harmony:

ʃtijepus	/s-ti-jep-us/	‘he tells him’	(*[stijepus])
ʃiʃlusisin	/s-iʃ-lu-sisin/	‘they (2) are gone awry’	(*[sislusisin])
ʃiʃtiʔi	/s-is-tiʔ/	‘he finds it’	(*[sistiʔ])

From a synchronic point of view, the markedness constraint responsible for the neutralization observed in Ineseño might be defined as in (5).[1] Note that the constraint is here formulated as

[1] The analysis of Ineseño sibilant harmony developed here glosses over an important aspect of the data. The contextual neutralization in precoronal contexts takes place only in *hetero-*

a targeted constraint (see §4.3.1), which compares relevant *pairs* of output candidates: those that differ minimally from each other in the presence vs. absence of the (contextually) marked feature specification.

(5) $\rightarrow$*[+ant] / __ [+ant] (henceforth $\rightarrow$**PRECOR**)

Let *x* and *x*′ be two candidate output representations, each of which contains a consonant cluster C_iC_j where C_i and C_j are both [coronal], and C_j is [+anterior]. Candidate *x*′ is preferred over *x* ($x' \succ x$) iff *x*′ is exactly like *x* except that in *x*′, the C_i consonant is [–anterior] rather than [+anterior].

Given a candidate pair like […sn…s…] vs. […ʃn…s…], the constraint in (5) will prefer the latter over the former, since the two are absolutely identical except for the fact that the former contains a targeted sibilant (alveolar [s] in the context __[n]) which the latter has 'replaced' with its [–anterior] counterpart [ʃ].

Recall from §4.3.1 above that the ranking required for deriving right-to-left sibilant harmony in Ineseño was $\rightarrow$IDENT[±anterior]-CC >> IDENT[±anterior]-IO. The tableau in (6) shows how the blocking effect in precoronal sibilants arises from the ranking $\rightarrow$PRECOR >> $\rightarrow$IDENT[±ant]-CC >> IDENT[±ant]-IO (/s-ti-jep-us/ → [ʃtijepus] 'he tells him'). As before, the $C_1 \leftarrow C_2$ correspondence relation between the two sibilants is indicated by subscript 'x'; the presence of this relation is enforced by a high-ranked CORR-C↔C constraint, not shown in the tableau.

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morphemic contexts, where the two coronals are separated by a morpheme boundary (Applegate 1972, Poser 1982, 1993, to appear, Kiparsky 1993, McCarthy 2006). Within a morpheme, clusters like [st], [sl], [sn], etc., do surface intact (cf. [wastu] 'pleat', [slow̓] 'eagle'). The (overt) effects of the constraint $\rightarrow$PRECOR should thus be somehow restricted to heteromorphemic clusters. When properly restricted, $\rightarrow$PRECOR would have no (overt) effect on morpheme-internal clusters, and should not block harmony from affecting sibilants in such clusters; this is precisely what happens in Ineseño. For example, the underlying /ʃ/ of /uʃla/ 'with the hand' does undergo harmony in /uʃla-sɨq/ → [uslasɨq] 'to press firmly by hand'. Since the sibilant + coronal cluster is tautomorphemic (root-internal), sibilant harmony is not blocked by $\rightarrow$PRECOR. See McCarthy (2006) for a detailed analysis of the precoronal effect in Chumash and its interaction with sibilant harmony, which provides indirect support for the analysis of consonant harmony as featural agreement as opposed to feature spreading.

(6) Ineseño: precoronal effect overrides sibilant harmony

/s-tijep-us/	→PRECOR	→ID[±ant]-CC	ID[±ant]-IO
a. $s_X$tijepus_X	b ≻ a		
b. ☞ $ʃ_X$tijepus_X		(a ≻ b)	(a ≻ b)
c. $ʃ_X$tijepu$ʃ_X$			{a, b} ≻ c; (d ≻ c)
d. $s_X$tijepu$ʃ_X$	c ≻ d	c ≻ d	a ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	(a ≻ b); c ≻ d	a ≻ c; b ≻ c; a ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d

Note that with respect to the fully harmonic (and fully faithful) but ungrammatical (6a) and the actual disharmonic output (6b), the preference relations expressed by the two targeted constraints, →PRECOR and →IDENT[±ant]-CC, are polar opposites. As a result, the ordering a ≻ b asserted by the latter is overridden, and fails to carry over into the cumulative ordering. From →PRECOR alone it is thus clear that the winner must be either (6b) or the 'reverse-harmonized' candidate (6c). The harmony-driving constraint →IDENT[ant]-CC is unable to discriminate between those two candidates, as it only compares candidates that differ *only in the* C_1 *member* of a $C_1 \leftarrow C_2$ correspondence mapping but are otherwise exactly identical (see §4.3.1 above). The decision between (6b) and (6c) thus falls to IDENT[±ant]-IO: since (6b) is more faithful, it emerges as the optimal output candidate.

The tableau in (7) shows that a [–anterior] specification arising from the precoronal effect will in turn act as a trigger of anticipatory sibilant harmony (/s-is-tiʔ/ → [ʃiʃtiʔi] 'he finds it').

(7) Ineseño: precoronal effect feeds sibilant harmony

/s-is-tiʔ/	→PRECOR	→ID[±ant]-CC	ID[±ant]-IO
a. s_Xi$s_X$tiʔ	b ≻ a		
b. s_Xi$ʃ_X$tiʔ		c ≻ b	(a ≻ b)
c. ☞ $ʃ_X$i$ʃ_X$tiʔ			({a, b, d} ≻ c)
d. $ʃ_X$i$s_X$tiʔ	c ≻ d	a ≻ d	a ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	c ≻ b; a ≻ d	({a, b, d} ≻ c); (a ≻ b); a ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

Again, $\overrightarrow{\text{PRECOR}}$ compares only those pairs of candidates that differ exclusively in having the (contextually) marked [+anterior] vs. unmarked [–anterior] distinction in a sibilant in pre-coronal position. Hence (7b) is preferred over (7a), as the two are otherwise identical, and likewise (7c) is preferred over the admittedly bizarre (7d). The contenders for the status of optimal output are (7b) and (7c). Unlike in (6) above, these two candidates *are* comparable with respect to $\overrightarrow{\text{IDENT}}$[±ant]-CC: they are identical except for containing the minimally distinct sibilant sequences [$s_x…ʃ_x$] vs. [$ʃ_x…ʃ_x$], and differ in the C_1 member of these sibilant pairs (i.e. at the 'receiving end' of the asymmetric $C_1 \leftarrow C_2$ correspondence relation). $\overrightarrow{\text{IDENT}}$[±ant]-CC prefers harmonic (7c) over disharmonic (7b), as well as preferring fully-faithful (7a) over the outrageous (7d) option. Combining these orderings with those asserted by top-ranked $\overrightarrow{\text{PRECOR}}$, the result is the cumulative ordering c ≻ b ≻ a ≻ d. The optimal output is thus (7c), in which harmony is being fed by the precoronal effect.

A somewhat more complicated example, which simultaneously displays both the override and the feeding relationship is shown in (8), which accounts for the derivation /s-iʃ-lu-sisin/ → [ʃiʃlusisin] 'they (two) are gone awry'. To keep things simple, the fourth sibilant is ignored in the output representations shown in the tableau. The first three sibilants are related in two pairs of CC-corresponding sibilants, $S_x…S_x$ and $S_y…S_y$, as was done in the account of iterative harmony in the previous chapter (see example (49) in §4.3.1 above). In the candidate [$s_x iʃ_{x,y} lus_y isin$] (8a), the output [ʃ] is simultaneously the C_2 member of the pair [$s_x…ʃ_x$] as well as being the C_1 member of the pair [$ʃ_y…s_y$]. The agreement constraint $\overrightarrow{\text{IDENT}}$[±ant]-CC potentially targets the C_1 member of any CC-corresponding sibilant pair. For this reason, the constraint is able to compare candidate (8a) to each of (8b) and (8c). In the (8a) vs. (8b) comparison, the relevant sibilant sequence is $S_y…S_y$ ([$ʃ_y…s_y$] vs. [$s_y…s_y$]), whereas the relevant sequence is $S_x…S_x$ in the (8a) vs. (8c) comparison: [$s_x…ʃ_x$] vs. [$ʃ_x…ʃ_x$]. Hence the harmonic orderings b ≻ a and c ≻ a.

Note that in the particular example in (8), the precoronal sibilant happens to be *underlyingly* [–anterior] (the relevant morpheme is the DualSubj prefix /iʃ-/). However, this has no bearing on the outcome of the derivation; the same output candidate would have been optimal even if the input had been the hypothetical /s-is-lu-sisin/ rather than /s-iʃ-lu-sisin/.[2]

[2] This is because low-ranked IDENT[±ant]-IO has hardly any effect at all on the choice of optimal output. From the orderings expressed by $\overrightarrow{\text{PRECOR}}$ >> $\overrightarrow{\text{IDENT}}$[±ant]-CC alone, it is clear that the winning candidate will be either (8c) or (8e). Regardless of whether the input is /s-is-lu-sisin/ or /s-iʃ-lu-sisin/, (8e) would have one more violation of IO faithfulness, and thus c ≻ e by IDENT[±ant]-IO. In either case, (8c) stands out as the only candidate which is not dispreferred relative to some other candidate.

(8) Ineseño: simultaneous blocking and feeding of sibilant harmony

/s-iʃ-lu-sisin/	→PRECOR	→ID[±ant]-CC	ID[±ant]-IO
a. s$_{x}$iʃ$_{x,y}$lus$_{y}$i…		$(b \succ a)$; $c \succ a$	
b. s$_{x}$is$_{x,y}$lus$_{y}$i…	$a \succ b$		$a \succ b$
c. ☞ ʃ$_{x}$iʃ$_{x,y}$lus$_{y}$i…		$(d \succ c)$	$(a \succ c)$
d. ʃ$_{x}$is$_{x,y}$lus$_{y}$i…	$c \succ d$	$b \succ d$	$\{a, b, c\} \succ d$
e. ʃ$_{x}$iʃ$_{x,y}$luʃ$_{y}$i…			$\{a, b, c\} \succ e$
f. s$_{x}$iʃ$_{x,y}$luʃ$_{y}$i…		$e \succ f$	$\{a, b, c\} \succ f$
Harmonic ordering by constraint	$a \succ b$; $c \succ d$	$(b \succ a)$; $c \succ a$; $(d \succ c)$; $b \succ d$; $e \succ f$	$a \succ b$; $(a \succ c)$; $\{a, b, c\} \succ d$; $\{a, b, c\} \succ \{e, f\}$
Cumulative harmonic ordering	$a \succ b$; $c \succ d$	$c \succ a \succ b \succ d$; $e \succ f$	☞ $\mathbf{c} \succ a \succ b \succ \begin{cases} d \\ e \succ f \end{cases}$

Note that out of the six candidates considered here, only the pairs (8a–b) and (8c–d) are comparable for the purposes of →PRECOR; these are the only pairs of candidates that re absolutely identical except for the [±anterior] value of the precoronal sibilant being targeted by this constraint. The only harmonic orderings contributed by →PRECOR as such are thus $a \succ b$ and $c \succ d$.

Of the various harmonic orderings asserted by →IDENT[±ant]-CC over the candidate set in (8), the most important ones are $b \succ a$, $c \succ a$ and $b \succ d$. The first of these directly contradicts higher-ranked →PRECOR and is therefore overridden. As a result, the cumulative ordering yields $c \succ a \succ b \succ d$ (combining $c \succ a$ and $b \succ d$ from →IDENT[±ant]-CC and $a \succ b$ from →PRECOR). In addition, →IDENT[±ant]-CC prefers the bizarre (8d) option over (8c), but this too is overridden by higher-ranked →PRECOR. Finally, note that →IDENT[±ant]-CC additionally asserts $e \succ f$. The candidates that are left in the running are thus (8e), in which harmony in [–anterior] emanates *bidirectionally* from the precoronal [ʃ], and the correct output (8c), in which the precoronal effect simultaneously blocks sibilant harmony (from the right) and feeds it (to the left). The choice between the two falls to IDENT[±ant]-IO: as (8e) is less faithful than (8c), this constraint crucially contributes $c \succ e$ to the overall ordering. The winning output candidate is therefore correctly defined as (8c).

5.1.2. Scenario II: Harmony Overrides Contextual Markedness

The Ineseño sibilant harmony case analyzed in §5.1.1 illustrates what happens when a contextual markedness constraint dominates →IDENT[ant]-CC, as in (3a) above. In that situation, the result is that the phonotactic restriction overrides harmony in case of conflict, but will otherwise feed the harmony wherever possible. In descriptive terms, the segment whose [±F] specification is governed by the markedness constraint can be characterized as ‘opaque’, in that it blocks the propagation of harmony from one direction but initiates a new harmonic span in the other direction.

We now turn to the (3b) ranking schema, where $^{\rightarrow}$IDENT[ant]-CC immediately dominates the context-sensitive markedness constraint, as shown in (9); as before, [X] and [Y] represent segments that differ in the feature [±F]. In (9a), there is generally a surface contrast [X] : [Y] in the language, neutralized in favor of [Y] in the environment A__B. In (9b), on the other hand, [X] and [Y] are generally in complementary distribution in the language.

(9) Harmony outranks (context-sensitive) markedness:

a. $^{\rightarrow}$IDENT[F]-CC >> $^{(\rightarrow)}$*X / A__B >> IDENT[F]-IO >> *Y

b. $^{\rightarrow}$IDENT[F]-CC >> $^{(\rightarrow)}$*X / A__B >> *Y >> IDENT[F]-IO

In the (9a) scenario, harmony would override the neutralization in A__B environments. Note that harmony can itself be seen as a case of contextual neutralization of the /X/ vs. /Y/ contrast. Before a following [X], the two are neutralized to [X] (/Y…X/ → [X…X], merging with underlying /X…X/); before [Y], they are neutralized to [Y] (/X…Y/ → [Y…Y], merging with /Y…Y/). What happens under the ranking in (9a) is that the /X/ : /Y/ contrast is normally neutralized to [Y] in the context A__B, *except* when harmony forces it to be neutralized to [X] instead: /AYB…X/ and /AXB…X/ are neutralized to [AXB…X], even though the structure [AXB] is otherwise not permitted in the language.

To illustrate this, let us imagine a language ‘Pseudo-Ineseño’, just like Ineseño except that the ranking is $^{\rightarrow}$IDENT[±ant]-CC >> $^{\rightarrow}$PRECOR >> IDENT[±ant]-IO. A comparison between the two systems is shown in (10). Firstly, both show the effect of the markedness constraint $^{\rightarrow}$PRECOR in cases where sibilant harmony is irrelevant (10a). Secondly, in both systems a sibilant which is [–anterior] due to $^{\rightarrow}$PRECOR will trigger [–anterior] harmony on any preceding sibilants (10b); in other words, the precoronal effect feeds harmony. The difference between the two systems will emerge in cases where there is a [+anterior] sibilant to the right of the precoronal one. In Ineseño, as we saw above, the precoronal effect overrides harmony, resulting in blocking; in Pseudo-Ineseño, by contrast, harmony overrides the precoronal effect, progressing unimpeded from right to left (10c).

(10) Ineseño vs. ‘Pseudo-Ineseño’ (with →IDENT[±ant]-CC >> →PRECOR)

		Ineseño		*Pseudo-Ineseño*
a.	/s-tepuʔ/	ʃtepuʔ	=	ʃtepuʔ
	/s-nit^{h}oj/	ʃnit^{h}oj	=	ʃnit^{h}oj
b.	/s-is-tɨʔ/	ʃiʃtɨʔɨ	=	ʃiʃtɨʔɨ
c.	/s-ti-jep-us/	ʃtijepus	≠	stijepus
	/s-iʃ-lu-sisin/	ʃiʃlusisin	≠	sislusisin

No consonant harmony systems quite like the Pseudo-Ineseño one appear to be attested. However, there does exist a striking case in which harmony overrides contextual markedness in a very similar manner, but where the overall ranking is as in (9b) rather than (9a). This is the sibilant harmony found in Nkore-Kiga (Runyankore-Rukiga), a dialect complex belonging to the Lacustrine group (‘Zone J’) of Bantu languages. The description presented here follows Hyman (1999b); the data are drawn from the computerized version of Taylor (1959), as incorporated into the *Comparative Bantu Online Dictionary (CBOLD)* lexicographic database (http://linguistics.berkeley.edu/CBOLD).[3]

In Nkore-Kiga, the sibilant fricatives rendered orthographically as <s> and <sh>, which will here be classified as [s] and [ʃ], are largely in complementary distribution, based on the quality of the following vowel; with some qualifications, the same thing can be said of the voiced counterparts [z] vs. [ʒ] as well. The distribution of these [+anterior] and [–anterior] variants, shown in (11), is somewhat counterintuitive, in that [–anterior] is the default realization, with [+anterior] surfacing only before the high front vowel [i]. In this respect, the distribution is the inverse of the more familiar pattern found, e.g., in Japanese ([ʃi] vs. [se], [sa], [so], [su]).

(11) Nkore-Kiga: distribution of [s] vs. [ʃ] and [z] vs. [ʒ] by following vowel

si	ʃu	zi	ʒu
ʃe	ʃo	ʒe	ʒo
ʃa		ʒa	

The same complementary distribution of [+anterior] and [–anterior] sibilants is found in the closely related language Haya (Byarushengo 1975, 1977; see also Hyman 2003:84–85). In Haya and Nkore-Kiga alike, the basic distributional pattern in (11) is obscured by one fact,

[3] The dialect complex that encompasses Nkore (Runyankore) and Kiga (Rukiga) will henceforth be treated jointly, and referred to as Nkore-Kiga, inasmuch as the two are extremely similar and seem to behave identically with respect to sibilant harmony. It should be noted, however, that the data from Taylor (1959) are drawn almost exclusively from Kiga. Poletto (1998) is a recent study covering various issues in the phonology of Nkore, but it makes no mention of sibilant harmony.

which renders it somewhat opaque. In prevocalic environments, a high front vocoid (< Proto-Bantu *į) gets absorbed into a preceding sibilant. Thus, for example, a root-final sibilant regularly surfaces as [s] due to fusion with the following causative allomorph /-i-/: /…S-i-a/ → […sa] (presumably via historically earlier *[…sja] by glide absorption). The causative counterpart of Haya [ʃáːʃa] = /SáːS-a/ 'ache, hurt (intrans.)' is thus [ʃáːsa] = /SáːS-i-a/ 'hurt (trans.)'.[4] This means that sequences like […sa…] do occur on the surface in Haya, but can generally be parsed quite straightforwardly as /…S-i-a…/. The relative distribution of [s] vs. [ʃ] is thus predictable. The following discussion will mostly avoid the complications involving causative /-i-/, focusing more on the near-allophonic distribution as depicted in (11).

What distinguishes Nkore-Kiga from Haya is that it has overlaid a system of anticipatory (regressive, right-to-left) sibilant harmony on top of the Haya distribution. Thus, for example, the causative verb pair /SáːS-a/ vs. /SáːS-i-a/ does not surface as [ʃáːʃa] vs. [ʃáːsa], as it does in Haya (see above), but as [ʃáːʃa] vs. [sáːsa]. Sibilant harmony is found in a number of Bantu languages of the Lacustrine group, including Rwanda (Kinyarwanda; Kimenyi 1979, Mpiranya & Walker 2005, Walker & Mpiranya 2005, Walker et al. 2008) and Rundi (Kirundi; Ntihirageza 1993), but the Nkore-Kiga system is rather unique. Generally speaking, all sibilants in a word will agree in [±anterior], with the rightmost sibilant determining the [±ant] value of all of them. In this respect, Nkore-Kiga is much like any other directional sibilant harmony system, but with one very important difference. The [±ant] value of the rightmost sibilant—the harmony trigger—is not specified underlyingly (as it would be in Ineseño, Navajo, and so forth) but rather *predictable*, based on the quality of the (underlyingly) following vowel. Some examples illustrating this are given in (12). The first column shows the underlying representation, again using archiphonemic /S/ to indicate the absence of any /s/ : /ʃ/ contrast. The second column shows how these forms would be expected to surface were it not for the effects of sibilant harmony (and some do indeed take that shape in the closely related Haya). The third column shows the actual form as attested in Nkore-Kiga.

(12) Directional sibilant harmony in Nkore-Kiga

		Expected	*Actual*	
a.	/-SaːSir-a/	*-ʃaːsira	-saːsira	'pity; forgive'
	/-SaːS-ire/	*-ʃaːsire	-saːsire	'be in pain (perf.)'
	/-SaSi/	*-ʃasi	-sasi	'porch'
	/-SeːS-i/	*-ʃeːsi	-seːsi	'attacker'
b.	/-SígiS-a/	*-sígiʃa	-ʃígiʃa	'stir [millet]'
	/-SiːS-a/	*-siːʃa	-ʃiːʃa	'do wrong, sin'
	/-SiS-a/	*-siʃa	-ʃiʃa	'be fat'
	/-Sîn(d)Z-a/	*-sîndʒa	-ʃîndʒa	'testify against'

[4] Since they are generally not contrastively specified for [±anterior], underlying sibilants in Haya and Nkore-Kiga are represented as /S, Z/ here and in the following discussion.

Sibilant harmony, when combined with the phonotactic restrictions on the distribution of [s] vs. [ʃ], frequently gives rise to alternations in the surface realization of individual morphemes. Consider, for example, such verb pairs as [-ʃaːʃa] 'be in pain' vs. perfective [-saːsire], [-ʃíʃa] 'compensate' vs. perfective [-sísire], and [-ʃîndʒa] 'testify against' vs. perfective [-sînzire], all involving the productive suffix /-ire/.

In all of the cases cited in (12), the two sibilants are tautomorphemic, co-occurring within the same root. This is by no means necessary; a suffix sibilant may trigger harmony in the preceding stem. For example, /gend-es-erer-i-a/ 'cause to leave for' is realized not as *[dʒendeʃereza] (/r+i/ → [z]) but as [dʒendesereza], with [s…z] rather than [ʃ…z].[5] This further illustrates that Nkore-Kiga sibilant harmony is a directional right-to-left harmony, just like the Ineseño harmony analyzed in §4.3.1 and §5.1.1 above.

To account for the complementary distribution of [+anterior] and [–anterior] sibilants, we need to appeal to a context-sensitive markedness constraint banning [+ant] sibilants before [i]. A possible formulation—again, defined as a *targeted* constraint—is given in (13).

(13) $\vec{\ }$NO[ʃi]

Let *x* and *x´* be two candidate output representations, each of which contains a sibilant fricative *S* followed by a high front vowel [i]. Candidate *x´* is preferred over *x* ($x' \succ x$) iff *S* is [+anterior] in *x´* whereas it is [–anterior] in *x*, and candidates *x´* and *x* are otherwise identical.

In other words, given two output candidates that are absolutely identical except that one has […si…] where the other has […ʃi…], $\vec{\ }$NO[ʃi] will prefer the former over the latter. It is important to note that $\vec{\ }$NO[ʃi] does not address the relative well-formedness of pairs of candidates which differ in other respects in addition to the [si] vs. [ʃi] distinction. For example, $\vec{\ }$NO[ʃi] will prefer [ʃasi] over [ʃaʃi], but it will not prefer [sasi] over [ʃaʃi], as these differ in the initial sibilant as well as the [si] vs. [ʃi] distinction targeted by the constraint.

In order to have any effect, the constraint $\vec{\ }$NO[ʃi] must outrank a general (context-free) markedness constraint against [+anterior] sibilants, referred to here simply as *[s].[6] To ac-

[5] Note that the root-initial /g/ becomes [dʒ] before the front vowel [e]. The affricates that arise through this general palatalization process do not interact in any way with the sibilant harmony holding between fricatives in Nkore-Kiga.

[6] Since [s] is generally assumed to be less marked than [ʃ], the relatively high ranking of a constraint *[s] may seem dubious. Nevertheless, something like this scenario seems to be required to account for the facts of Nkore-Kiga (as well as those of Haya, and possibly other closely related languages as well). It is possible that the transcriptions [s] and [ʃ] (and the featural analysis in terms of [±anterior]) do not accurately reflect the phonetics of this contrast in the languages in question. This is a question that will have to be left to future investigation;

count for the complementary distribution of [+ant] and [–ant] sibilants, it must further be assumed that both →NO[ʃi] and *[s] dominate the faithfulness constraint IDENT[±ant]-IO:

(14) Nkore-Kiga: ranking for complementary distribution of [s] vs. [ʃ]

→NO[ʃi] >> *[s] >> IDENT[±ant]-IO

The way in which anticipatory sibilant harmony is 'superimposed' on the overall distribution pattern of [s] vs. [ʃ] can be captured by taking →IDENT[±ant]-CC to dominate all the constraints in (14). This is shown in (15). As before, we gloss over the fact that the presence of a C_1←C_2 correspondence relation between sibilants is ultimately due to a high-ranked CORR-C↔C constraint. Since IDENT[±ant]-IO is ranked to low to have any effect, it is omitted from the tableau, and input sibilants are shown as /S/, as their underlying [±anterior] specifications are immaterial.

(15) Nkore-Kiga: anticipatory harmony from a (predictably) [+anterior] sibilant

/-SeːS-ire/	→ID[±ant]-CC	→NO[ʃi]	*[s]
a. -ʃ$_{x}$eːs$_{x}$ire	b ≻ a		(c ≻ a)
b. ☞ -s$_{x}$eːs$_{x}$ire			({a, c, d} ≻ b)
c. -ʃ$_{x}$eːʃ$_{x}$ire		a ≻ c	
d. -s$_{x}$eːʃ$_{x}$ire	c ≻ d	b ≻ d	c ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	a ≻ c; b ≻ d	(c ≻ a); (a ≻ b); (c ≻ b); (d ≻ b); c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d	(b ≻ a ≻ c ≻ d)

In (15), the constraints →IDENT[±ant]-CC and →NO[ʃi] jointly determine the outcome. Low-ranked *[s] is unable to have any effect; indeed, the optimal output (15b) does worse on that constraint than any of its competitors. Note that in this case, there is no conflict between the ordering relations asserted by →IDENT[±ant]-CC and →NO[ʃi]. The markedness constraint →NO[ʃi] simply 'feeds' the anticipatory sibilant harmony required by →IDENT[±ant]-CC, resulting in (15b) being optimal.

The tableau in (16) shows the opposite scenario, where the phonotactics would predict a [+ant]…[–ant] sequence ([s…ʃ]). Here →IDENT[±ant]-CC and →NO[ʃi] do not exhaustively determine the cumulative harmonic ordering of output candidates (and in part contradict each

in any case, it does not bear directly on the 'mechanics' of Nkore-Kiga sibilant harmony, its absolute directionality, and its interaction with phonotactics.

other in this respect). As a result, low-ranked *[s] is able to contribute preference relations that crucially help determine the optimal output.

(16) Nkore-Kiga: anticipatory harmony from a (predictably) [–anterior] sibilant

/-Si:S-a/	→ID[±ant]-CC	→NO[ʃi]	*[s]
a. -ʃ$_X$i:s$_X$a	b ≻ a	b ≻ a	c ≻ a
b. -s$_X$i:s$_X$a			{c, d} ≻ b; (a ≻ b)
c. ☞ -ʃ$_X$i:ʃ$_X$a		(d ≻ c)	
d. -s$_X$i:ʃ$_X$a	c ≻ d		c ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	b ≻ a; (d ≻ c)	c ≻ a; (a ≻ b); c ≻ b; d ≻ b; c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	b ≻ a; c ≻ d	☞**c** ≻ d ≻ b ≻ a

In this kind of case, →NO[ʃi] contributes nothing beyond what →IDENT[±ant]-CC already does, and the cumulative ordering based on these two constraints is simply b ≻ a and c ≻ d; the winner is therefore destined to be either (16b) with perseveratory [+ant] harmony or the correct (16c) with anticipatory [–ant] harmony. The constraint *[s] decides between the two, contributing the crucial preference c ≻ b, which defines (16c) as optimal.

In (16), the correct outcome crucially depends on the contextual markedness constraint →NO[ʃi] being formulated as a targeted constraint. In (17) we see how the derivation fails if a *non*-targeted constraint (here *[ʃi]) is substituted for →NO[ʃi].

(17) Nkore-Kiga: incorrect result with non-targeted *[ʃi] constraint

/-Si:S-a/	→ID[±ant]-CC	*[ʃi]	*[s]
a. -ʃ$_X$i:s$_X$a	b ≻ a	{b, d} ≻ a	c ≻ a
b. ☞ -s$_X$i:s$_X$a			({a, c, d} ≻ b)
c. ☹ -ʃ$_X$i:ʃ$_X$a		b ≻ c; (d ≻ c)	
d. -s$_X$i:ʃ$_X$a	c ≻ d		c ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	b ≻ a; d ≻ a; b ≻ c; (d ≻ c)	c ≻ a; (a ≻ b); (c ≻ b); (d ≻ b); c ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ c ≻ d ≻ a	(b ≻ c ≻ d ≻ a)

The crucial difference is that, unlike targeted →NO[Si], non-targeted *[ʃi] *does* prefer (16b)/(17b) over (16c)/(17c). In terms of harmonic ordering relations, *[ʃi] simply asserts that *any* candidate that contains a […ʃi…] sequence is worse than *any* candidate that does not. By contrast, targeted →NO[Si] asserts that a candidate with a […ʃi…] sequence is worse than a candidate that has […si…] in its place and is *otherwise identical* to it.

The fundamental difference between the sibilant harmony systems of Ineseño and Nkore-Kiga can be summed up as follows. In Ineseño, phonotactic restrictions are able to override harmony, whereas in Nkore-Kiga, it is harmony that overrides the phonotactics. What is remarkable about the latter case is that it is those very same phonotactic restrictions that create the sibilant distinctions upon which the harmony operates; surface [±anterior] values of sibilants are predictable rather than underlyingly specified. Despite these differences, Ineseño and Nkore-Kiga behave alike in that the phonotactics *feed* the consonant harmony wherever applicable. In Ineseño, the manifestation of this is that when a sibilant is forced to be [–anterior] due to the precoronal effect, it will itself trigger [–ant] harmony on any preceding sibilants. In Nkore-Kiga, the phonotactics feed harmony in the sense that they determine the [±anterior] value of the rightmost sibilant—the only one that is immune to harmony (by not being the C_1 member of any $C_1 \leftarrow C_2$ correspondence pair)—and this sibilant then triggers [+ant] or [–ant] harmony on any preceding sibilants.

5.1.3. Scenario III: Contextual Markedness Interleaved with Similarity Hierarchy

In the preceding sections we have seen how the relative ranking of context-sensitive markedness constraints with →IDENT[F]-CC can give rise to various override effects. In the analyses of Ineseño and Nkore-Kiga, the presence of a $C_1 \leftarrow C_2$ correspondence mapping was ensured by the high ranking of the relevant CORR-C↔C constraints. In these cases, the undominated status of the CORR-C↔C constraints demanding correspondence between co-occurring sibilants meant that we were in practice able to limit the candidate set under consideration to those candidates in which $C_1 \leftarrow C_2$ correspondence was present (i.e. $S_x \ldots S_x$ rather than $S_x \ldots S_y$). But what about the relative ranking of a context-sensitive markedness constraint and the CORR-C↔C constraints themselves? Is it possible for phonotactics to interfere with harmony not by overriding →IDENT[F]-CC (as in Ineseño), but by overriding the very establishment of a correspondence relation between the two consonants? The answer is yes; a case of precisely this type of interaction will be dealt with here.

Recall from §4.2 that harmony results jointly from a CORR-C↔C constraint, which imposes a $C_1 \leftarrow C_2$ correspondence relation, and an →IDENT[F]-CC constraint requiring that C_1 agree with C_2 in feature [F]. As we saw in the analysis of Ngizim voicing harmony in §4.2.3, both constraints need to be ranked high enough in order for harmony to take effect. If →IDENT[F]-CC is ranked too low, then 'unfaithful' CC correspondence can arise (i.e. C_1 may disagree with C_2 in terms of [±F]). On the other hand, if the relevant CORR-C↔C constraint is ranked too low, then a $C_1 \leftarrow C_2$ correspondence mapping may not be imposed, in which case →IDENT[F]-CC will be irrelevant (and hence vacuously satisfied).

In the case of Ngizim voicing harmony, the inertness of (voiced) sonorants was accounted for by the fact that CORR-[voi,son] (the constraint responsible for establishing correspondence between obstruents and sonorants) was dominated by IO faithfulness to [±voice]; see tableau (31) in §4.2.3. Given an input sequence like /t…r/, it is then more important to preserve the input [–voice] specification of /t/ than it is to establish a $C_1 \leftarrow C_2$ correspondence relation between the output correspondents of /t/ and /r/. Since the harmony constraint →IDENT[+voice]-CC is undominated, $C_1 \leftarrow C_2$ correspondence would entail forcing [+voice] harmony: /t…r/ → [d_x…r_x]. But due to the low ranking of CORR-[voi,son], the best alternative is instead to sacrifice $C_1 \leftarrow C_2$ correspondence. Since this renders →IDENT[+voi]-CC irrelevant, it makes it possible to obey IO faithfulness. The optimal output is then [t_x…r_y], without $C_1 \leftarrow C_2$ correspondence and (therefore) without harmony.

In the Ngizim case, the antagonistic constraint—the one that may interfere with harmony by outranking either →IDENT[F]-CC or CORR-C↔C—is faithfulness to the harmony feature, IDENT[F]-IO. But the antagonist might as well be a markedness constraint. For harmony to apply, →IDENT[F]-CC and CORR-C↔C must both outrank *any* constraint that militates against harmony in some way. In §5.1.1 above we saw how harmony is overridden when a context-sensitive markedness constraint dominates →IDENT[F]-CC (without also dominating CORR-C↔C). This scenario is repeated in (18a). The same kind of override effect can arises when a markedness constraint instead dominates CORR-C↔C, as shown in (18b).

(18) Contextual markedness overriding harmony: two alternative scenarios

a. CORR-C↔C >> ***X / A__B** >> **→IDENT[F]-CC** >> IDENT[F]-IO

b. →IDENT[F]-CC >> ***X / A__B** >> **CORR-C↔C** >> IDENT[F]-IO

In principle, the result is no different in the two cases in (18); harmony is simply blocked whenever it would result in a structure that violates the higher-ranked markedness constraint, by producing a […AXB…] sequence. Recall, however, that CORR-C↔C constraints form a hierarchy based on the relative similarity of the two consonants involved (as well as their relative proximity). This allows for a subtle difference between the (18b) and (18a) scenarios: it is possible for a markedness constraint to dominate only a subset of the CORR-C↔C hierarchy, as in (19).

(19) Interleaving of markedness with similarity-based CORR-C↔C hierarchy:

→ID[F]-CC, **CORR-[F,G] >> *X / A__B >> CORR-[F,G,H]** >> ID[F]-IO

The result here is that the markedness constraint overrides correspondence between consonants that differ in *all* of the features [F], [G] and [H]. Hence harmony (in terms of [±F]) is blocked from applying between such consonants if enforcing it would result in the prohibited structure […AXB…]. In the case of consonants that differ *only* in [F] and [G] (i.e. ones that already agree in [H]), the demand for correspondence is stronger than the markedness constraint against [...AXB...]. As a result, the phonotactic ban on [...AXB...] structures blocks harmony between less similar segments, but is unable to block harmony between more similar segments. As it turns out, there are attested cases of consonant harmony that have exactly this character.

In the Nguni subgroup of the Bantu language family, some languages display a morpheme-internal laryngeal harmony, whereby (non-click) stops are required to agree in their laryngeal feature specifications (Hyman 1999a, Hansson 2004a, Sibanda 2004; see §2.4.7 for details). For example, Khumalo (1987) states that in Zulu, co-occurring stops are either all aspirated, all fully voiced or all unspecified for laryngeal features.[7] The harmony is illustrated by the verb stems in (20). Khumalo adds that 'a very careful study of regular disyllabic roots in Zulu has revealed no counter-examples to consonant harmony' (Khumalo 1987:26). Besides being a valid generalization over the native Zulu lexicon, the existence of laryngeal harmony is also corroborated by loanword phonology, as shown by examples like (20d), where the rendering of English word-final /t/ is governed by harmony with a preceding stop in the same morpheme. The pattern in (20) can be interpreted as agreement due to a constraint $\overrightarrow{\text{IDENT}}$[Laryngeal]-CC, where [Laryngeal] may be construed as the feature-geometric class node dominating the relevant features, or else as a feature class in the spirit of Padgett (2002).

(20) Morpheme-internal laryngeal harmony in Zulu (Khumalo 1987)

a.	-pet-a	'dig up'	(T…T)
	-táp-a	'collect (honey, etc.)'	(T…T)
b.	-k^{h}et^h-a	'to choose'	(T^h…T^h)
	-p^{h}át^h-a	'to hold'	(T^h…T^h)
c.	-gub-a	'to dig'	(D…D)
d.	í-k^{h}ôt^{h}o	'court' (< Eng. *court*)	
	úm-bídi	'conductor' (< Eng. *beat*)	

As discussed in §2.4.7 above, the agreement pattern in (20) is overridden by a phonotactic limitation on the distribution of velar stops. In Zulu, aspirated [k^h] is restricted to root-initial position (Khumalo 1987:58). In closely related Ndebele, the exact same laryngeal harmony

[7] Khumalo (1987) uses [+aspirated] for the aspirates, and [+depressed] for the fully voiced stops, owing to the role that the latter play as tonal depressors. As discussed in §2.4.7 above, the phonetic realization of the 'unspecified' stops /p, t, k/ varies depending on environment: they are phonetically ejectives in some contexts, and /k/ is realized as a voiced fricative in other environments. In the following discussion, these consonants are transcribed as [p, t, k] throughout, but it should be kept in mind that this abstracts away from some potentially important aspects of phonetic detail.

obtains as in Zulu, along with the same restriction against non-initial [k^h] (Sibanda 2004).[8] Setting aside non-initial velars for the moment, Hyman (1999a) found, based on a search of /C_1VC_2…/ verb stems in a computerized version of a Ndebele dictionary (Pelling 1971), that out of 172 verb stems where both C_1 and C_2 are (non-click) stops, only 3 violate the harmony pattern. (Of these three exceptions, two share the same root, with /k^h…d/; the third has /d…p^h/).

When C_2 is a velar stop, however, the markedness constraint against non-initial [k^h] clearly overrides the demand for laryngeal harmony. The verb-stem search revealed no examples of harmonic /p^h…k^h/ or /t^h…k^h/; instead we consistently find /p^h…k/, /t^h…k/, as (21) illustrates.

(21) Ndebele heterorganic stops: phonotactics overrides harmony (Pelling 1971)

-p^hek-a	'cook, brew'
-p^hik-a	'argue, deny'
-t^huk-a	'abuse, curse'

In examples like the ones in (21), C_1 is either labial or coronal, whereas C_2 is velar; the two stops are thus heterorganic, disagreeing in both place of articulation and (due to the phonotactic restriction on [k^h]) in laryngeal features. When C_1 is velar, however, harmony instead overrides markedness, giving rise to [k^h] in the non-initial C_2 position.

(22) Ndebele homorganic stops: harmony overrides phonotactics (Pelling 1971)

-k^hok^h-a	'pull, draw out'
-k^huk^h-ul-a	'sweep away'

Instead of disharmonic [k^h…k], which would be expected, based on the pattern in (21), we consistently find fully harmonic [k^h…k^h]. (Consider also loanwords such as Zulu [-k^hek^he] 'cake'.) In sum, the interaction of markedness and harmony in Ndebele is not as simple as in Ineseño or Nkore-Kiga. Markedness overrides laryngeal harmony between heterorganic stops, but is itself overridden by laryngeal harmony between homorganic stops.

In order to capture the Ndebele and Zulu pattern, we must first account for the general absence of [k^h] from non-root-initial position. It seems reasonable to assume that this pattern is not due to a context-sensitive markedness constraint, since 'not in root-initial position' is not a well-defined environment. Instead, let us take this to be due to a context-free marked-

[8] See the detailed discussion in §2.4.7 above (as well as Hansson 2004a) for some additional complications of the harmony pattern, especially as regards the participation of [g] and the patterning of ejective [p', t', k'] as well as the velar continuant [ɣ]. The discussion below focuses on the restriction on [k^h] and its interaction with harmony; the question of how to deal with the behavior of [g] and the ejectives is left open.

ness constraint *[k^h], dominated by a positional faithfulness constraint preserving laryngeal features in root-initial position, referred to here as IDENT[Lar]-IO$_{RTONS}$. An underlying /k^h/ is thus prevented from surfacing intact *except* in root-initial position, where it is protected by positional faithfulness.

Two CORR-C↔C constraints are relevant for laryngeal harmony in Ndebele and Zulu. The first of these is CORR-[Lar], which demands $C_1 \leftarrow C_2$ correspondence between stops that differ *at most* in their laryngeal features. This covers homorganic sequences: [p^h…b], [d…t], [k^h…k], [b…b], [t^h…t^h], and so forth. The second constraint is CORR-[Lar, Place], which calls for a $C_1 \leftarrow C_2$ correspondence relation between stops that differ at most in their laryngeal and place features. In addition to the homorganic sequences covered by CORR-[Lar], this constraint also encompasses heterorganic sequences like [p^h…t], [d…k], [k^h…b], [b…g] or [t^h…k^h]. The ranking between these two CORR-C↔C constraints is fixed, as part of the similarity hierarchy (see §4.2.1.1 above): CORR-[Lar] >> CORR-[Lar, Place].

As explained above, the ban on non-initial [k^h] results from the combination of positional faithfulness and (context-free) markedness: IDENT[Lar]-IO$_{RTONS}$ >> *[k^h]. The latter takes the place of the markedness constraint *X / A__B in the interleaving schema of (19) above, resulting in the following ranking:

(23) Ndebele and Zulu: interleaving of CORR-C↔C hierarchy and markedness

{ ID[Lar]-IO$_{RTONS}$, CORR-[Lar] } >> *[k^h] >> CORR-[Lar, Place] >> …

In (24) we see how laryngeal harmony applies in cases where *[k^h] is irrelevant. The example given is [-p^hát^ha] 'hold' from (20b); in order to demonstrate how laryngeal harmony is forced in this type of case, the root has been assigned the hypothetical underlying representation /-p^hád-/. Since the stops are heterorganic, the relevant CORR-C↔C constraint is CORR-[Lar, Place]; the higher-ranked CORR-[Lar] is omitted from the tableau. Since neither stop is velar, *[k^h] is irrelevant and has been left out of the tableau as well.

Top-ranked $\rightarrow$IDENT[Lar]-CC asserts (24d) ≻ (24b): given $C_1 \leftarrow C_2$ correspondence, anticipatory harmony beats disharmony. Positional IDENT[Lar]-IO$_{RTONS}$ prefers any candidate over (24c) or (24d). However, the ordering b ≻ d is overridden by a higher-ranked constraint; what IDENT[Lar]-IO$_{RTONS}$ crucially contributes to the cumulative ordering is b ≻ c as well as {a, e, f} ≻ d. Combined with the already-established ordering d ≻ b, this narrows down the set of conceivable winners to (24a), (24e) and (24f). The decision between the three falls to CORR-[Lar, Place], which prefers (24f) over each of the other two (f ≻ {a, e}). Thus (24f) is the optimal output.

(24) Ndebele: laryngeal harmony between heterorganic stops (*[k^h] irrelevant)

/-p^hád-a/	→ID[Lar]-CC	ID[Lar]-IO$_{RTONS}$	CORR-[Lar, Place]	ID[Lar]-IO
a. -$p^h{}_X$ád_Ya			({b, d} ≻ a); f ≻ a	
b. -$p^h{}_X$ád_Xa	d ≻ b			
c. -b_Xád_Ya		{a, b, e, f} ≻ c	{b, d, f} ≻ c	{a, b} ≻ c
d. -b_Xád_Xa		{a, e, f} ≻ d; (b ≻ d)		a ≻ d; (b ≻ d)
e. -$p^h{}_X$á$t^h{}_Y$a			({b, d} ≻ e); f ≻ e	a ≻ e; (b ≻ e)
f. ☞ -$p^h{}_X$á$t^h{}_X$a				({a, b} ≻ f)
Harmonic ordering by constraint	<u>d ≻ b</u>	<u>{a, e, f} ≻ {c, d}</u>; <u>b ≻ c</u>; (b ≻ d)	<u>f ≻ {a, e}</u>; {b, d, f} ≻ c; ({b, d} ≻ {a, e})	a ≻ {c, d}; <u>a ≻ e</u>; (a ≻ f); b ≻ c; (b ≻ {d,e,f})
Cumulative harmonic ordering	d ≻ b	{a, e, f} ≻ d ≻ b ≻ c	☞**f** ≻ {a, e} ≻ d ≻ b ≻ c	(f ≻ a ≻ e ≻ d ≻ b ≻ c)

Note that the result of the ranking in (23)/(24) is *perseveratory* (left-to-right) harmony issuing from the root-initial stop, the one that is protected by positional faithfulness. In effect, this is parallel to the phenomenon of stem control discussed in §4.3.2. Just as a ranking →IDENT[F]-CC >> IDENT[F]-SA >> IDENT[F]-IO gives rise to perseveratory harmony under stem control, the ranking →IDENT[F]-CC >> IDENT[F]-IO$_{RTONS}$ >> IDENT[F]-IO will generate perseveratory harmony by a kind of 'root-onset control'. Loanwords like those in (20d) confirm this pattern: the realization of C_2 is dependent on that of root-initial C_1, rather than vice versa.

The next tableau shows how the markedness constraint *[k^h] overrides harmony between heterorganic stops. The example is [-p^hek-a] 'cook, brew'; to illustrate the forced disharmony in such cases the input is hypothetically posited as /-p^hek^h-a/. This surfaces with a disagreeing [p^h…k] rather than agreeing [p^h…k^h] or [p…k]. To reduce clutter, CORR-[Lar] has again been omitted from the tableau, as has low-ranked IDENT[Lar]-IO.

(25) Ndebele: *[k^h] overrides laryngeal harmony between heterorganic stops

/-p^hek^h-a/	→ID[Lar]-CC	ID[Lar]-IO$_{RTONS}$	*[k^h]	CORR-[Lar, Place]
a. -$p^h{}_x$e$k^h{}_y$a			c ≻ a; ({d, e, f} ≻ a)	b ≻ a; ({d, f} ≻ a)
b. -$p^h{}_x$e$k^h{}_x$a			c ≻ b; ({d, e, f} ≻ b)	
c. ☞ -$p^h{}_x$ek_ya				({b, d, f} ≻ c)
d. -$p^h{}_x$ek_xa	f ≻ d			
e. -p_xek_ya		{a,b,c,d} ≻ e		{b, d, f} ≻ e
f. -p_xek_xa		{a, b, c} ≻ f; (d ≻ f)		
Harmonic ordering by constraint	<u>f ≻ d</u>	<u>{a, b, c} ≻ {e, f}</u>; <u>d ≻ e</u>; (d ≻ f)	<u>c ≻ {a, b}</u>; ({d, e, f} ≻ {a, b})	<u>b ≻ a</u>; (b ≻ c); ({d, f} ≻ {a, c}); {b, d, f} ≻ e
Cumulative harmonic ordering	f ≻ d	{a, b, c} ≻ f ≻ d ≻ e	☞**c** ≻ {a, b} ≻ f ≻ d ≻ e	(c ≻ b ≻ a ≻ f ≻ d ≻ e)

Undominated →IDENT[Lar]-CC prefers (25f)—in which /k^h/ → [k] feeds anticipatory harmony, resulting in /p^h…k^h/ → [p…k]—over candidate (25d), which shows /k^h/ → [k] but no harmony; hence f ≻ d. This ordering overrides positional faithfulness (IDENT[Lar]-IO$_{RTONS}$) which would otherwise prefer (25d) over (25f). What that constraint does contribute to the cumulative ordering is {a, b, c} ≻ {e, f} as well as d ≻ e. When this is combined with the already-established f ≻ d, it becomes clear that the optimal output will be either (25a), (25b) or (25c). The choice between the three falls to *[k^h], which prefers (25c) over the other two; hence (25c) is optimal.[9]

Note that top-ranked →IDENT[Lar]-CC is dependent on the presence of a C_1←C_2 correspondence relation (C_x…C_x); without such a relation this constraint is irrelevant. The reason why disharmonic (25c) is able to emerge as the winner is because it *sacrifices* C_1←C_2 correspondence, thereby making the (undominated) demand for harmony vacuous, in the interest of simultaneously satisfying root-onset faithfulness and the prohibition on (root-medial) [k^h].

[9] The same candidate, (25c), would also win if the input were disharmonic /-p^hek-a/. This is because general IO faithfulness to the laryngeal specifications of the root-internal stop (IDENT[Lar]-IO) is ranked below *[k^h], such that the former has no effect at all on output selection.

What makes this possible is the fact that the CORR-C↔C constraint that is relevant in this case, CORR-[Lar, Place], is ranked low enough to be violable.

When the two stops are homorganic, higher-ranked CORR-[Lar] becomes relevant; this constraint dominates the markedness constraint *[k^h]. In this case, it is more important to establish a $C_1 \leftarrow C_2$ correspondence relation between the two stops than it is to uphold the ban against medial [k^h]. In (26) we see how a (hypothetically) disagreeing input /-k^hok-a/ is harmonized to [-k^hok^ha]. The low-ranked constraints CORR-[Lar, Place] and IDENT[Lar]-IO) are omitted to save space.

(26) Ndebele: laryngeal harmony between homorganic stops overrides *[k^h]

/-k^hok-a/	→ID[Lar]-CC	ID[Lar]-IO_{RTONS}	CORR-[Lar]	*[k^h]
a. -$k^h{}_x$ok_ya			d ≻ a; ({b, f} ≻ a)	({e, f} ≻ a)
b. -$k^h{}_x$ok_xa	f ≻ b			(e ≻ b); f ≻ b
c. -$k^h{}_x$o$k^h{}_y$a			d ≻ c; ({b, f} ≻ c)	a ≻ c; ({b, e, f} ≻ c)
d. ☞ -$k^h{}_x$o$k^h{}_x$a				({a,b,e,f} ≻ d)
e. -k_xok_ya		{a,b,c,d} ≻ e	{b, d, f} ≻ e	
f. -k_xok_xa		{a, c, d} ≻ f; (b ≻ f)		
Harmonic ordering by constraint	f ≻ b	b ≻ e; (b ≻ f); {a,c,d} ≻ {e,f}	d ≻ {a, c}; {b, d, f} ≻ e; ({b, f} ≻ {a, c})	(f ≻ a); f ≻ b; a ≻ c; ({b, f} ≻ c); ({a, b, f} ≻ d); (e ≻ {a,b,c,d})
Cumulative harmonic ordering	f ≻ b	{a, c, d} ≻ f ≻ b ≻ e	☞**d** ≻ {a, c} ≻ f ≻ b ≻ e	(d ≻ a ≻ c ≻ f ≻ b ≻ e)

Here the two highest-ranked constraints, →IDENT[Lar]-CC and IDENT[Lar]-IO_{RTONS}, jointly narrow down the candidate set to (26a), (26c), and (26d). CORR-[Lar] resolves this tie in favor of (26d). In the case of homorganic stops, perseveratory (left-to-right) harmony is thus preferred over disharmony, even at the cost of violating the prohibition against [k^h] outside of root-initial position.

What the Ndebele (and Zulu) case shows us is that phonotactics, due either to context-sensitive markedness or to context-free markedness curtailed by positional faithfulness, is able to override consonant harmony not by outranking the agreement constraint $\rightarrow$IDENT[F]-CC but by outranking the relevant CORR-C↔C constraint. Given that CORR-C↔C constraints are arranged in a similarity-based hierarchy, we expect it to be possible for a phonotactic restriction to override harmony between relatively less similar segments while itself being overridden by harmony in the case of a more similar trigger-target pair. Laryngeal harmony in Ndebele and Zulu confirms this prediction.[10]

5.2. Morpheme-Internal Harmony

In the discussion of directionality effects and their analysis in §4.3 above, the major distinction drawn was between morphology-sensitive harmony (obeying stem control) and morphology-insensitive harmony (obeying anticipatory directionality). This dichotomy determines the directionality of assimilation in heteromorphemic contexts (stem + suffix; prefix + stem). But what about morpheme-*internal* consonant co-occurrence, where constituent structure and stem control is irrelevant? The prediction would seem to be that morpheme-internal harmony should always exhibit anticipatory (regressive, right-to-left) assimilation. As noted in the typological overview of chapter 2, a great number of consonant harmony systems are limited to root-internal contexts. It is therefore important to explore whether this prediction appears to be validated.

First of all, it should be noted that in many cases, the directionality of root-internal harmony is simply indeterminable. This is generally the case when the harmony is a *featurally symmetric* (or 'double-value') system, in which [–F] and [+F] alike can trigger assimilation. When all we know is that [αF]…[αF] sequences are allowed in roots but *[αF]…[–αF] ones are not, it is impossible to tell whether this is because a disharmonic input [αF]…[–αF] se-

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[10] One issue which has not been addressed here is the fact that the disharmonic [k] appears to be *transparent*, at least in Zulu (see §2.4.7). In loanwords, the rendering of English word-final /t/ is governed by harmony across an intervening /k/: /-p^háket^{h}e/ 'packet', /-bakêde/ 'bucket'. Otherwise the default rendering is /t^h/, cf. /-máket^{h}e/ 'market' (Khumalo 1987). In this respect, disharmonic [k] in Zulu is different from the disharmonic [ʃ] in Ineseño that results from the precoronal effect; the latter is *opaque* in the sense that it initiates a new harmony span on its other side (see §5.1.1 for illustration). It is tempting to try to derive this difference from the type of markedness interaction involved. In Ineseño, CORR-C↔C is undominated, and all three sibilants in a S…ʃt…S sequence are thus forced to stand in correspondence with each other. In Zulu, by contrast, CORR-C↔C is ranked low enough that correspondence can be sacrificed, if need be. Hence T_1 and T_2 in a T…k…T sequence are able to correspond across the intervening [k], without either of them standing in a correspondence relation to the [k]. Exactly how to account for this difference in formal terms will be left as a topic for further investigation.

quence would assimilate progressively to [αF]…[αF] or regressively to [–αF]…[–αF].[11] Most root-internal harmony systems are of this kind, and do therefore not bear on the question of directionality in any way.

In *featurally asymmetric* ('single-value') harmony systems, where only one of the two feature values is active, it is occasionally possible to detect directionality effects. We have already encountered one example of such a system: Ngizim obstruent voicing harmony. As was discussed in detail in §4.2.3, this case displays anticipatory directionality: [–voi]…[+voi] sequences harmonize to [+voi]…[+voi] (/k…z/ → [g…z]), whereas [+voi]…[–voi] sequences (/b…k/) are left unassimilated. Ngizim voicing harmony thus seems to fit our expectation that, other things being equal, morpheme-internal harmony will show the anticipatory default.

But note that synchronically, our evidence of directionality in Ngizim harmony is nothing more than an asymmetry of attestation: possible output sequences include agreeing D…D, T…T and disagreeing D…T, but crucially not *T…D. It would be equally possible, at least in principle, to account for this asymmetric distribution by invoking perseveratory [–voice] harmony rather than anticipatory [+voice] harmony. Concretely, the difference between these two analyses lies in whether a hypothetical input /T…D/ would be assumed to merge with input /D…D/ (as [D…D]) or instead with input /T…T/ (as [T…T]). Since all we see is the attested output forms, and there is no reason to posit a disharmonic underlying representation for any actual Ngizim root, we have no direct synchronic evidence that speaks in favor of anticipatory [+voice] harmony specifically. What evidence we do have is external to the synchronic grammar of Ngizim. On the one hand we can appeal to *historical-comparative* evidence, e.g., that /gâːzá/ 'chicken' and /zə̀dù/ 'six' correspond to Hausa /kàːzáː/ and /ʃídà/, respectively. Another source of evidence, even more oblique, is *typological-comparative*: other obstruent voicing harmony systems seem to involve [+voice] rather than [–voice] as the active feature value (e.g. Kera; see §2.4.7). On the basis of such external evidence, it seems reasonable to surmise that Ngizim voicing harmony does indeed follow anticipatory directionality.

Sometimes synchronic language-internal evidence does exist, such as when the directional asymmetry seen in morpheme-internal contexts is also evident in heteromorphemic contexts, and where the direction of assimilation is manifested overtly in the latter. As an example, consider stricture harmony in the Oceanic language Yabem (see §2.4.6). In this language, a prefixal /s/ assimilates to a homorganic stop ([t], [d] or [ⁿd]) in the following stem.[12] Some examples are shown in (27). The assimilation is here characterized as obligatory, fol-

[11] It is also conceivable that the directionality of assimilation depends on the feature values involved. For example, [+F]…[–F] might assimilate progressively (yielding [+F]…[+F]) whereas [–F]…[+F] assimilates regressively (yielding the same output, [+F]…[+F]). See the discussion of featurally asymmetric ('single-value') harmony below.

[12] Sources from different periods disagree on whether prenasalized [ⁿd] triggers harmony, or only the plain stops [t], [d]; see §2.4.6 for further discussion of this issue.

lowing Dempwolff (1939), but according to Ross (1995) stricture harmony is optional in present-day Yabem (presumably due to levelling of the [s] ~ [t]/[d] alternations).[13]

(27) Stricture harmony in Yabem 3Pl /se-/ prefix

a.	sé-líʔ	/se-líʔ/	'see (3Pl realis/irrealis)'	(Ross 1995)
b.	té-táŋ	/se-táŋ/	'weep (3Pl realis/irrealis)'	(Ross 1995)
	dè-dèŋ	/se-dèŋ/	'move towards (3Pl realis)'	(Ross 1995)
c.	té-dàgùʔ	/se-dàgùʔ/	'follow (3Pl realis)'	(Dempwolff 1939)

The apparent directionality here is anticipatory, but since it is also stem-to-affix, stem control might instead be involved. Furthermore, the harmony is featurally asymmetric, with the feature value [–continuant] being the active one. A prefixal coronal stop, such as the /t/ of the 1Pl inclusive prefix /ta-/, will not assimilate to a stem-initial /s/: /ta-sùŋ/ → [dàsùŋ] 'we (incl.) push', /ta-sèlèŋ/ → [tásèlèŋ] 'we (incl.) wander'. The evidence from heteromorphemic contexts is thus that homorganic [+cont]…[–cont] sequences ([s…t], [s…d]) are subject to anticipatory harmony, yielding [+cont]…[+cont], while [–cont]…[+cont] sequences ([t…s], [d…s]) surface intact and unaffected by harmony.

This is mirrored exactly by the static co-occurrence patterns found within roots. Native morphemes in the Yabem lexicon do not contain /s…t/ or /s…d/ sequences (Dempwolff 1939, Bradshaw 1979, Ross 1995). Non-homorganic fricative-stop sequences are allowed, however, just as they are in prefix + stem contexts: /sákíŋ/ 'service', /sàb^{w}àʔ/ 'potsherd; spleen'). On its own, this morpheme-internal co-occurrence restriction could be interpreted in two ways. A hypothetical input like /s…t/ does not surface intact, either because it undergoes anticipatory [–cont] harmony (yielding [t…t]), or because it undergoes perseveratory [+cont] harmony (surfacing as [s…s]). This is the same indeterminacy we encountered in the Ngizim case above, but with one difference: in Yabem we can appeal to the evidence from heteromorphemic contexts to settle the question. The unattested morpheme-internal sequences /s…t/ and /s…d/ are precisely the ones that actively undergo anticipatory [–cont] harmony when they arise across a prefix-stem boundary, as in (27). Even though it is impossible to observe morpheme-internal harmony 'in action', as it were, the convergence of the morpheme-internal and heteromorphemic facts suggest that Yabem stricture harmony follows anticipatory directionality, with [–continuant] as the active feature value.

Occasionally, other types of synchronic language-internal evidence can be help determine the directionality of morpheme-internal consonant harmony. For example, the harmony may be fed by other (morpho-)phonological alternations that affect root consonants. Where an

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[13] The realization of harmonized /s/ as [t] or [d] is predictable from tone-voicing interaction (Hansson 2004b), and is irrelevant here; see §3.3.2 for discussion. Note that the stem-initial stop needs to be homorganic in order to trigger stricture harmony. Roots with non-coronal stops (/gàb^{w}àʔ/ 'untie'), do not induce stricture harmony in the /se-/ prefix.

independently motivated alternation threatens to give rise to root-internal disharmony, we are able to observe directly in what manner that disharmony is avoided: by anticipatory or perseveratory assimilation. A case in point is the coronal harmony found in many Western Nilotic languages, discussed in §2.3 and §2.4.1.2 above. In these languages, contrastively alveolar and dental consonants are not allowed to co-occur within the root, as illustrated by the Päri forms in (28a). Consonants that are redundantly alveolar, such as /l/ and /r/, are free to co-occur with dentals and alveolars alike (28b).[14]

(28) Root-internal coronal harmony in Päri (data from Andersen 1988)

a. Well-formed roots with multiple coronals

t̪ʊ̀ɔn̪	'male'
n̪ɔt̪	'sucking'
d̪á:n̪-ɛ́`	'person (ergative)'
àtwá:t`	'adult male elephant'
àdú:nd-ó`	'heart'

b. Redundantly alveolar /l, r/ are neutral (no dental /l̪, r̪/ in inventory)

tìɛl	'legs'
-t̪ɔ̀:l`-ì	'ropes'
rʊ̀:t	'grind'
rwʌ̀t̪	'chief'

Based on the static co-occurrence patterns in (28a) alone, we have no obvious way of determining whether Päri coronal harmony is inherently anticipatory (predicting /d…n̪/ → [d̪…n̪]) or perseveratory (/d…n̪/ → [d…n]), or whether the directionality is feature-based, for example with alveolars assimilating to dentals regardless of linear order. The crucial evidence comes from the interplay of coronal harmony with other phenomena in the grammar of Päri. As mentioned in §2.3 and §2.4.1.2 above, Western Nilotic languages make extensive use of root-final consonant alternations in their derivational and inflectional morphology (see, e.g., Andersen 1988, 1999, Tucker 1994, Reh 1996). The alternations that are most directly relevant involve replacing a root-final /l/ with either [t] or [nd], or appending [n(:)] to a vowel-final root. In contexts where coronal harmony is irrelevant, these 'derived' root-final consonants are consistently alveolar, not dental, e.g. [bò:**t**-â] 'my handles' from /bò:l-/, [á-gò:**nd**-é] 'they scratched it' from /gò:l-/. But in those cases where this root-final alternation threatens to yield a disharmonic dental…alveolar sequence, coronal harmony is enforced. In Päri, the root-final alveolar yields to the root-initial dental, resulting in a surface dental…dental sequence, as shown in (29).

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[14] In some Western Nilotic languages, such as Alur and Luo, /n/ is redundantly alveolar as well, and is likewise neutral with respect to coronal harmony.

(29) Päri: root-final alternations feed coronal harmony (Andersen 1988)

	Unpossessed	*Possessed (1Sg)*	
a.	dèːl	dèːnd-á	‘skin’ vs. ‘my skin’
	t̪ùol	t̪úon̪d̪-à	‘snake’ vs. ‘my snake’
b.	tà-à	tàːnː-á	‘pancreas’ vs. ‘my pancreas’
	ùt̪ó`-ó	ùt̪óːn̪`-á	‘fox’ vs. ‘my fox’

It appears, then, that root-internal coronal harmony in Päri obeys *perseveratory* (left-to-right) directionality, since it is the root-final consonant that yields to the root-initial one. Interestingly, the opposite directionality seems to hold in the related Shilluk (Gilley 1992). In Shilluk, just as in Päri, contrastively dental vs. alveolar stops or nasals are prohibited from co-occurring root-internally: /t̪î̱n̪/ ‘small’, /ti̱n/ ‘today’ (underlining indicates [+ATR]). But unlike the Päri situation in (29), it is the root-initial dental that yields to a derived root-final alveolar. Thus the Shilluk verb root /t̪al/ ‘cook (trans.)’ is realized as [ta̱ːt in the antipassive and as [tā̱ːd-ā] in the instrumental (not *[t̪a̱ːt̪] and *[t̪ā̱ːd̪-ā], respectively). Unlike its Päri counterpart, then, Shilluk coronal harmony does show the expected anticipatory directionality.

How can we account for the perseveratory directionality in Päri? There are two main possibilities. One is to adopt an analysis similar to that of Bantu nasal consonant harmony in §4.3.3, effectively treating dentality ([+distributed]) as the ‘active’ feature value by invoking a ranking IDENT[+dist]-IO >> IDENT[–dist]-IO. As long as the ranking $^{\rightarrow}$IDENT[–dist]-CC >> IDENT[+dist]-IO also holds, the correct pattern will result. A second alternative is to invoke stem control. This may seem odd, given that the consonants in question are tautomorphemic.[15] Take as an example the pair [t̪ùol] ‘snake’ vs. [t̪úon̪d̪-à] ‘my snake’ in (29). Were it not for coronal harmony, the possessed form should be [t̪úond-à]. Unlike the root-final alveolar [nd], which only shows up in certain morphologically derived forms, the root-initial dental [t̪] is constant across all surface realizations of the root, including the basic form [t̪ùol]. If the output form of /t̪ùol/ ‘snake’ is construed as the base of derivation for the possessed form ‘my snake’, the IO and SA correspondence dimensions can be mapped out as in (30).

[15] This is a matter of perspective, of course; rather than treat the alternations as a matter of allomorphy, one might view the root-final coronals as separate affix morphemes which somehow ‘overwrite’ part of the segmental content of the root. Of potential relevance is the fact that the root-final [t, n, nd] that show up under the consonant alternations in (29) were almost certainly independent suffixes historically (cf. Hall & Hall 1996 on antipassive formation with /-t/). Nevertheless, it is still true that the co-occurrence restriction needs to be somehow explicitly limited to the ‘root’—in some relevant sense—as its domain of application. The appropriate constituent might perhaps be prosodic rather than a morphosyntactic (a ‘prosodic root’ or PRoot; Inkelas 1990, Inkelas & Zoll 2005).

(30) Päri: orthogonal dimensions of IO vs. SA correspondence

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 / t̪ùol /                        / t̪úond-à /
    ↓                                ↓
(IO-Faith)                       (IO-Faith)
    ↓                                ↓
 [ t̪ùol ]   → (SA-Faith) →      [ t̪úon̪d̪à ]
```

Let us assume that the [t̪] of the derived output form **[**t̪úon̪d̪à**]** corresponds to the initial [t̪] of the base [t̪ùol] by SA-correspondence, but that the nasal+stop cluster [n̪d̪] is *not* a correspondent of the base-final [l] in this way. If so, the dentality of the root-initial /t̪/ is protected directly by IDENT[dist]-IO as well as indirectly (via the [t̪] of the base output [t̪ùol]) by IDENT[dist]-SA. The alveolarity of the root-final /nd/ in the possessed form, on the other hand, is protected only by IO faithfulness, not SA correspondence. The ranking for stem control, namely $^{\rightarrow}$IDENT[F]-CC >> IDENT[F]-SA >> IDENT[F]-IO, will then produce the right result, as shown in (31).

Top-ranked $^{\rightarrow}$IDENT[dist]-CC prefers anticipatory harmony over disharmony (b ≻ a), whereas faithfulness to the base of affixation, in the form of IDENT[dist]-SA, prefers perseveratory harmony over anticipatory harmony (c ≻ b). As a result, the optimal output has the root-final consonant(s) assimilating to the root-initial one rather than vice versa.

(31) Päri: root-initial to root-final harmony as stem control

Input: /t̪úond-à/ *Stem:* [t̪ùol]	$^{\rightarrow}$ID[±dist]-CC	ID[±dist]-SA	ID[±dist]-IO
a. t̪$_X$úond$_X$à	b ≻ a		
b. t$_X$úond$_X$à		(a ≻ b); c ≻ b	(a ≻ b)
c. ☞ t̪$_X$úond̪$_X$à			(a ≻ c)
d. t$_X$úon̪d̪$_X$à	c ≻ d	{a, c} ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	b ≻ a; c ≻ d	(a ≻ b); a ≻ d c ≻ b; (c ≻ d)	(a ≻ {b, c}); {a, b, c} ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

Yet another alternative would be to appeal to *positional* faithfulness to the root-initial onset rather than to SA faithfulness, much like in the Ndebele and Zulu laryngeal harmony analyzed in §5.1.3 above. If a positional faithfulness constraint IDENT[distr]-IO$_{\text{RTONS}}$ were substituted for IDENT[distr]-SA in the tableau in (31), the exact same result would obtain. However, though it is true that the Päri facts could be interpreted either as stem control or as 'positional control', only the latter option is amenable to Ndebele and Zulu.

There are other cases of perseveratory harmony within roots that can be captured by appealing to positional faithfulness in root-initial consonants in just this way outlined here. In Tlachichilco Tepehua (Watters 1988), dorsal consonant harmony, whereby velar and uvular stops assimilate to each other, normally applies in a right-to-left fashion, from stem to prefix, as described in §2.4.2 above. Root-internally, however, harmony can also be seen to interact with a phonotactic requirement that coda stops or nasals (i.e. non-continuants) must be dorsal. An underlying /p/ will surface as [p] in onset position but as [wk] in coda position; similarly, /t/ is realized as [t] in onsets and as [k] in codas. As mentioned in §2.4.2 (see also §3.1.3), this process of coda dorsalization feeds dorsal consonant harmony. An underlying root with the structure /-qVt-/ will surface as [-qV.t-] when the root-final consonant is syllabified as an onset (that is, before a vowel-initial suffix), just as expected. When that consonant is syllabified as a coda, dorsalization would be expected to yield *[-qVk.-]. This would violate dorsal consonant harmony, and we instead find [-qVq.-]. The directionality of harmony is thus left-to-right: the root-final stop yields to the root-initial one. This is illustrated schematically in (32). The undominated markedness constraint responsible for coda dorsalization is omitted from the tableau; all candidates under consideration obey it. The velar vs. uvular contrast is represented here in terms of [±RTR], though the choice of feature has no bearing on the issue.

(32) Tlachichilco Tepehua: dorsal consonant harmony with 'root-onset control'

/qVt-CV/	$^{\rightarrow}$ID[±RTR]-CC	ID[±RTR]-IO$_{RTONS}$	ID[±RTR]-IO
a. q_XVk_X.CV	b ≻ a		
b. k_XVk_X.CV		(a ≻ b); c ≻ b	(a ≻ b)
c. ☞ q_XVq_X.CV			(a ≻ c)
d. k_XVk_X.CV	c ≻ d	{a, c} ≻ d	{a, b, c} ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>; <u>c ≻ d</u>	(a ≻ b); <u>a ≻ d</u> <u>c ≻ b</u>; (c ≻ d)	(a ≻ {b, c}); {a, b, c} ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**c** ≻ b ≻ a ≻ d	(c ≻ b ≻ a ≻ d)

In general, the cases of morpheme-internal consonant harmony in the database surveyed in this work can be accounted for with the analytical machinery developed in this and the previous chapter. Inasmuch as their directionality can be determined at all, the majority of root-internal consonant harmony systems display the expected anticipatory directionality. The remaining ones, where perseveratory directionality is observed, can all be accounted for by appealing to positional faithfulness in root-initial consonants, as in Tlachichilco Tepehua or the Ndebele/Zulu case analyzed in §5.1.3 above.[16]

[16] See also the discussion of canonical Bantu nasal consonant harmony in §4.3.3.

In a small number of cases, there is tentative evidence—usually *diachronic* rather than synchronic—to suggest that the harmony operates bidirectionally, as an effectively 'dominant-recessive' system in which the active feature value triggers both anticipatory and perseveratory assimilation. One example of this is sibilant harmony in Basque, which prohibits apico-alveolar and lamino-alveolar sibilants from co-occurring within a morpheme (Hualde 1991, Trask 1997). When harmony is enforced in loanword adaptation, laminals tend to assimilate to apicals rather than vice versa, regardless of the order of the two, indicating that apical is the active or 'dominant' value and laminal the 'recessive' one. The same asymmetry is seen when compounds are reanalyzed as simplex words, and thus subjected to the morpheme-internal harmony requirement. Examples involving anticipatory assimilation are /fran(t)s̺es̺/ 'French' < /fran(t)ses̺/ (from Spanish *francés*) and the reanalyzed compound /s̺inets̺i/ 'believe' < /sin-ets̺i/ (cf. /sin/ 'truth', /(h)ets̺i/ 'consider'). Perseveratory assimilation is seen in forms like /s̺ats̺uri/ 'mole' (17th century; originally a compound */s̺at-suri/) and /s̺as̺oi(n)/ < */s̺asoi(n)/ from Spanish *sazón* (Michelena 1985).[17]

Another potential example, though less clear-cut, is liquid harmony in Bukusu. As described in §2.4.5 above, Bukusu harmony results in a suffixal /l/ assimilating to an /r/ in the preceding stem, but it is also manifested root-internally as a static co-occurrence restriction, whereby /l/ and /r/ cannot co-occur. Bukusu /l/ and /r/ are generally the historical reflexes of Proto-Bantu (PB) **d* and **t*, respectively. The root-internal sequences **t...d* and **d...t* would be expected to yield /r…l/ and /l…r/ in Bukusu, were it not for liquid harmony. Interestingly, it appears that both /r…l/ and /l…r/ tend to get harmonized to /r…r/, which suggests that the [–lateral] feature value is 'dominant' and that the harmony applies bidirectionally. Thus, for example, /-rare/ 'iron/copper ore' goes back to PB **tade*, whereas /-reːr-a/ 'bring' and /-roːr-a/ 'dream' go back to PB **deːt-a* and **doːt-a*, respectively. Root-internal /l…l/ sequences in Bukusu are virtually always reflexes of Proto-Bantu **d...d* rather than resulting from liquid harmony (e.g., /-lilo/ 'fire' < PB **dido*, /-lol-a/ 'look at' < PB **dod-a*). Nevertheless, the overall picture of root-internal liquid harmony in Bukusu is muddled by much variation, which makes it less conclusive as case of bidirectional 'dominant-recessive' harmony.[18]

The analytical framework developed in this and the preceding chapter does allow for bidirectional consonant harmony, in which one feature value acts as the active or 'dominant' one, triggering assimilation in preceding and following consonants alike. The necessary rank-

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[17] In some dialects, regressive assimilation appears to prevail regardless of the feature value involved, e.g., */s̺asoi(n)/ > /sasoi/. Given the default status of anticipatory (right-to-left) directionality in the analysis developed in this work, the existence of such systems is only to be expected.

[18] For example, the verb stems just cited, /-reːr-a/ 'bring' and /-roːr-a/ 'dream', also have the disharmonic variants /-leːr-a/ and /-loːr-a/, respectively. Moreover, the former is even attested as /-leːl-a/, with perseveratory [+lateral] harmony. It is unclear to what extent this is truly 'free' variation, whether dialectal differences are involved, or what other factors might play a role.

ing is {→IDENT[+F]-CC, →IDENT[–F]-CC} >> IDENT[αF]-IO >> IDENT[–αF]-CC, where [αF] is the active feature value. (Note that this is a variation on the ranking laid out for Bantu nasal consonant harmony in §4.3.3 above, where only one of the →IDENT[F]-CC constraints outranked IO faithfulness.) That this is so is shown by the schematic derivations in (33) and (34), whereby a [+F]…[+F] output sequence regardless whether the input contains /–F…+F/ or /+F…–F/, respectively. In these tableaux, the two value-specific versions of the constraint →IDENT[F]-CC have been conflated into a single constraint to save space.

(33) A bidirectional 'dominant' system, I: anticipatory [+F] harmony:

/ –F…+F /	→IDENT[±F]-CC	IDENT[+F]-IO	IDENT[–F]-IO
a. –F…+F	b ≻ a		
b. ☞ +F…+F			({a, c} ≻ b)
c. –F…–F		{a, b} ≻ c	
d. +F…–F	c ≻ d	{a, b} ≻ d	{a, c} ≻ d
Harmonic ordering by constraint	<u>b ≻ a</u>; <u>c ≻ d</u>	<u>{a, b} ≻ c</u>; <u>{a, b} ≻ d</u>	({a, c} ≻ b); {a, c} ≻ d
Cumulative harmonic ordering	b ≻ a; c ≻ d	☞**b** ≻ a ≻ c ≻ d	(b ≻ a ≻ c ≻ d)

(34) A bidirectional 'dominant' system, II: perseveratory [+F] harmony:

/ +F…–F /	→IDENT[±F]-CC	IDENT[+F]-IO	IDENT[–F]-IO
a. +F…–F	c ≻ a		
b. ☞ +F…+F			({a, c} ≻ b)
c. –F…–F		(a ≻ c); b ≻ c	
d. –F…+F	b ≻ d	{a, b} ≻ d	{a, c} ≻ d
Harmonic ordering by constraint	<u>c ≻ a</u>; <u>b ≻ d</u>	(a ≻ c); <u>b ≻ c</u>; <u>a ≻ d</u>; b ≻ d	({a, c} ≻ b); {a, c} ≻ d
Cumulative harmonic ordering	c ≻ a; b ≻ d	☞**b** ≻ c ≻ a ≻ d	(b ≻ c ≻ a ≻ d)

Outside of morpheme-internal contexts—in which the evidence primarily comes from historical change and loanword adaptation—genuinely 'dominant-recessive' consonant harmony systems do not appear to be attested. Such a system would be one in which, for example, a sibilant that is [–anterior] triggers harmony on any and all preceding *and following* [+anterior] sibilants, regardless of whether the sibilants in question belong to affix (prefix, suffix) morphemes or roots. The fact that such systems are (as yet) unattested, despite being predicted to be possible, should hardly be taken as a weakness of the analysis. It is worth keeping in mind that even for vowel harmony, such bidirectional dominant-recessive systems are quite rare, and appear to be limited to harmonies based on tongue-root position ([±ATR]), a typological asymmetry which is yet to be explained (see Baković 2000).

5.3. Outstanding Issues

The analytical framework that has been developed in this work is a generalized treatment of consonant harmony, based on the idea that this phenomenon has its sources, diachronic and/or synchronic, in the domain of speech-production planning. The analysis has been tailored to capture the main empirical-typological generalizations discussed in chapters 2 and 3 above. However, a number of unanswered questions remain, which await further research.

5.3.1. Domain Restrictions

First of all, as was discussed in §3.3, consonant harmony is never sensitive to stress or other metrical structure, and it appears never to be bounded by genuinely prosodic domains such as the metrical foot. In this respect consonant harmony stands in sharp contrast both to vowel harmony and to what has here been labelled 'vowel-consonant harmony' (nasalization spreading, pharyngealization spreading, etc.), which are very frequently sensitive to prosodic structure. It is difficult to see how prosodically-bounded consonant harmony can be ruled out wholesale as a synchronic state of affairs; indeed, this is true under *any* analysis, not merely the one developed here. For example, any kind of positional faithfulness constraint that references a prosodically salient position will have the potential of influencing the directionality of consonant harmony, in much the same way as high-ranked SA correspondence (to the base of affixation) can lead to stem control. We have already seen how what looks like *morphologically* defined positional faithfulness to root-initial segments can result in 'root-onset control'. It would seem, then, that 'stressed-syllable control' ought to be equally possible, whereby consonant harmony would emanate from the stressed syllable to unstressed ones. The absence of such systems is likely to have more to do with the (diachronic) sources of consonant harmony interactions than what is or is not a synchronically possible (or learnable) phonological grammar.

Even though consonant harmony is never bounded by prosodic domains, it is worth noting that it is quite often limited to *morphologically* defined domains. Very frequently consonant harmony is enforced only within roots. Even when harmony does reach beyond the confines of the root, it is often limited to affixes of a relatively more lexicalized or 'derivational' nature, while leaving more productive and more transparently 'inflectional' affixes unaffected (e.g. dorsal harmony and sibilant harmony in Totonacan languages, nasal consonant harmony in Bantu languages).[19] Consonant harmony thus tends to be a *lexical* phenomenon, in something like the pre-OT sense of Lexical Phonology (Kiparsky 1982, 1985, Kaisse & Shaw 1985, Mohanan 1986), in that it is enforced at earlier/deeper strata (including within roots as such), without necessarily being enforced at later strata. In particular, there are no attested cases whatsoever of consonant harmony reaching beyond the domain of the morphological word, the way vowel harmony frequently does.[20] Consonant harmony is thus never a *postlexical* process.

It is not immediately clear how the confinement of consonant harmony to the root, or to some kind of intermediate 'stem' constituent, is best accounted for within a constraint-based and output-oriented OT analysis. One possibility is to appeal to the *co-phonology* notion (Inkelas 1996, 1997, 1999, Inkelas & Orgun 1998, Inkelas et al. 1997, Inkelas & Zoll 2005, Orgun 1994, 1996, 1997, 1999, Yu 2000a), whereby separate phonological grammars—with slightly different constraint rankings—can hold over different types of morphological constructions and domains. For example, a given language might have a ranking →IDENT[F]-CC >> IO-FAITH in the cophonology for roots—or in the co-phonology for derived stems (root + derivational affixes)—but the reverse ranking IO-FAITH >> →IDENT[F]-CC in the 'word-level' cophonology. The empirical generalization is then that cross-linguistically, consonant harmony tends to be found in those co-phonologies that are associated with relatively 'lexical' or 'inner' morphosyntactic constituents: roots and/or derivational constructions rather than inflectional constructions or entire words.

This is interesting in that vowel harmony appears to have a tendency to gravitate in precisely the opposite direction. In vowel harmony systems, disharmony is often rampant within roots, and exceptional behavior (e.g. exceptional non-undergoer status, or internal dishar-

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19 In the structure of the Bantu verb, suffixes are uncontroversially considered to be more closely bound to the root than are any prefixes. For example, in Downing's model of the Bantu verb (e.g. Downing 1999; see also Ngunga 2000) the verb root plus any so-called 'extensions'—which are mostly valence-changing suffixes (causative, passive, applicative, reciprocal, etc.)—constitute the Derivational Stem or D-Stem, which in turn joins with an inflectional suffix (e.g., perfective, subjunctive, or the ubiquitous 'empty' morph /-a/) to form the Inflectional Stem or I-Stem. Prefixes, on the other hand, mark subject and object agreement, tense, negation, and so forth. The I-Stem is the domain in which nasal consonant harmony holds (in those Bantu languages that have the harmony).

20 Numerous vowel harmony systems include clitics in the harmony domain, which may then be defined as the clitic group, or perhaps even the phonological phrase. For example, in some of the Cantabrian dialects of Spanish, most notably the Pasiego dialect, height and [ATR] harmony reaches proclitics and prepositions (Penny 1969a, 1969b, McCarthy 1984, Vago 1988, Hualde 1989). Another example is anticipatory [ATR] harmony in Karajá, which can be triggered by enclitics, and which even applies across a word boundary—as long as the two words forms a single prosodic unit, e.g. in possessive constructions like /wa-ritʃɔrɛ dʒ-u/ (1POSS-offspring REL-tooth) → [waritʃo̠re̠ˈdʒu] 'my child's tooth' (Ribeiro 2000).

mony) is more likely to be found in less productive, less transparent, more 'derivational' affixes. In their overview of vowel harmony phenomena, van der Hulst & van de Weijer (1995:502) expressly state that 'inflectional affixes are usually more regular undergoers of harmony than derivational affixes'. This typological asymmetry between vowel harmony and consonant harmony can be added to those discussed in chapter 3 above. The rather more 'lexical' character of consonant harmony is likely to have something to do with its diachronic sources, the ways in which it gets phonologized, and may well be tied to psycholinguistic factors of lexical storage and retrieval. This is most certainly an interesting topic of further investigation.

5.3.2. Contrastiveness and Similarity

Another major question concerns the role that contrast (the contrastive vs. redundant status of [±F] specifications) plays in defining eligible trigger-target pairs, and the way in which patterns of contrast may affect the assessment of relative (trigger-target) similarity. In general, the set of consonants that interact in any given consonant harmony system typically consists of those that are *contrastively* specified for the feature in question; segments that are redundantly [+F] (or redundantly [–F]) are completely inert and transparent to the harmony. For example, sonorants never participate in voicing harmony (even though they are [+voice]), nonsibilant coronals such as /t, d/ never participate in sibilant harmony (though they are [+anterior]), and so forth. In the analysis of Ngizim obstruent voicing harmony in §4.2.3, it was assumed that the inertness of sonorants was due to inadequate similarity between a [+voice] sonorant and a [–voice] obstruent. In effect, it was simply stipulated that any obstruent-sonorant pair, such as [d]-[l] or [b]-[m], is less similar than any obstruent-obstruent pair, such as [k]-[z] or [d]-[f]. As such, the failure of sonorants to trigger voicing harmony was made to fall out from the similarity hierarchy of CORR-C↔C constraints: given that an obstruent-sonorant pair is less similar, the demand for a CC correspondence relation between the two consonants will be weaker than in the case of an obstruent-obstruent pair.

This may not be the most appropriate explanation. In general, the correlation between inertness to consonant harmony involving [F] and redundancy of [±F] specifications is remarkably tight. For example, as was pointed out in the Ngizim analysis laid out in §4.2.3, implosives are also inert to voicing harmony. Just like the sonorants, these are predictably (i.e. redundantly) [+voice], and fail to trigger voicing harmony or interact with it in any way. The analysis in §4.2.3 was forced to stipulate that this, too, was a matter of relative similarity. But it seems rather suspect to assume that the members of a homorganic pulmonic vs. implosive stop pair like [t]-[ɗ] are *less* similar to each other than those of a heterorganic stop vs. fricative pair like [t]-[v], such that the latter, but not the former, will be subject to voicing harmony.[21]

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[21] See Hansson (2004a) for an alternative attempt at explaining the inertness of implosives in obstruent voicing harmony systems. There it is conjectured that such systems may arise by

Consider also the fact that in many sibilant harmony systems, entire sibilant series interact with each other, regardless of manner and laryngeal features, such as the contrasting [s, z, ts, dz, ts'] vs. [ʃ, ʒ, tʃ, dʒ, tʃ'] series in many Athapaskan languages, whereas non-sibilant coronal obstruents like [t, d, t'] are inert to sibilant harmony. We may assume that this is because sibilants like [ts] and [tʃ] are more similar to each other than either is to [t]. But because differences in laryngeal features or manner do not affect the harmony, we are forced to go much further and claim that even a pair like [z]-[tʃ'] is 'more similar' than a pair like [t']-[tʃ']. This is somewhat counterintuitive, given that [tʃ'] and [z] differ along far more dimensions than do [tʃ'] and [t']. Effectively, we are then stipulating that with respect to its impact on relative similarity, a match in [±strident] specifications (or perhaps [+strident] specifically) carries greater weight than do all of the features [±anterior, ±continuant, ±voice, ±constricted glottis] combined. This is not unthinkable, given that stridency is a very salient property in acoustic-perceptual terms. However, one may ask whether the fact that [±anterior] is redundant in non-sibilants like [t'] or [t], whereas it is contrastive in sibilants, is not also likely to be relevant.

An especially striking case in point is the morpheme-internal laryngeal harmony found in the Ijoid languages (Jenewari 1989), which involves the implosive vs. pulmonic distinction in voiced stops; see §2.4.7 above. In Bumo Izon, the voiced stop inventory is as shown in (35), following the description in Efere (2001).

(35) Voiced stops in Bumo Izon (Efere 2001)

labial	*coronal*	*velar*	*labial-velar*
b	d	g	
ɓ	ɗ		ɠ͡ɓ

Within morphemes, Bumo Izon does not allow implosive and pulmonic voiced stops to co-occur. Thus sequences like [b…b], [b…d] or [ɗ…ɓ] are allowed, but not *[ɓ…b], *[d…ɓ], *[b…ɗ], and so forth, as illustrated in (36a–b). However, the laryngeal harmony only regulates combinations of *contrastively* implosive stops with *contrastively* pulmonic (voiced) stops. The velar stop [g] is redundantly pulmonic (there exists no implosive [ɠ] in Bumo Izon), and freely co-occurs not only with the other pulmonic voiced stops [b, d], but also with the implosives [ɓ, ɗ, ɠ͡ɓ], as shown in (36c). Similarly, the doubly articulated labial-velar stop [ɠ͡ɓ] is redundantly implosive, since Bumo Izon lacks a pulmonic [g͡b]). This stop is likewise allowed to co-occur freely both with other implosives and with the pulmonic stops [b, d, g], as the examples in (36d) demonstrate.

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the analogical reanalysis of tone-voicing interactions (where implosives typically pattern with voiceless obstruents as tone raisers, whereas pulmonic voiced obstruents are tone depressors).

(36) Bumo Izon: laryngeal harmony and contrastiveness (data from Efere 2001)

a. ɓʊ́ɓaɪ 'yesterday' búbú 'rub (powder in face)'
ɗɔ́ːɗɔ́ː 'cold' bídɛ́ 'cloth'
ɗáɓá 'swamp'

b. *b…ɗ *ɓ…d *d…ɓ *ɗ…b

c. igódó 'padlock' ɗúgó 'to pursue'
ìdɛ́gɛ́ 'type of fish' ɓúgí 'to wring (hand)'

d. ɡ͡ɓáɓúː 'crack!' ɡ͡ɓódaɡ͡ɓoda '(rain) hard'
ɡ͡ɓíɾíɓúː 'not well-cooked'

This case is particularly striking in the way that contrastiveness plays a very direct role in delimiting the set of interacting segments in the co-occurrence restriction (see Mackenzie 2005). It is hard to see how the inertness of velars and labial-velars in Bumo Izon laryngeal harmony can be explained away as a similarity effect except by *ad hoc* stipulation. If anything, one might intuitively expect the opposite effect if similarity were at stake: [b] ought to count as being *less* similar to [ɗ] than [g] is, since [b] is (contrastively) *non*-implosive whereas [g] carries no contrastive specification for the implosive vs. pulmonic distinction.

Objective similarity metrics certainly do exist in which the distinction between contrastive and redundant feature values plays a role. This is true of the natural classes model (Broe 1993, Frisch 1996, Frisch et al. 2004). In this model, the similarity of two segments is computed as the ratio between the number of (distinct) natural classes that include both segments and the total number of (distinct) natural classes that include one or the other (or both), as shown in (37). The natural classes model has proven quite effective in accounting for psycholinguistic data (speech errors) as well as phonological patterning (Frisch 1996, 2001, 2004, Frisch & Zawaydeh 2001, Frisch et al. 2004; but see also Bailey & Hahn 2005).

(37) Natural classes model of similarity (Frisch et al. 2004)

$$\text{Similarity} = \frac{\text{Shared natural classes}}{\text{Shared natural classes} + \text{Non-shared natural classes}}$$

In the limiting case of total identity, similarity is of course equal to 1.0, since a segment is a member of all the same natural classes as itself. As usual, natural classes are defined as (partial) feature descriptions; thus [coronal, –sonorant] defines the class of all coronal obstruents, whereas [coronal, –sonorant, –voice] defines the narrower class of all voiceless coronal obstruents. Importantly, only *distinct* natural classes are counted; for example, if the language in question has no (phonemic) voicing contrast, the two aforementioned classes are extensionally equivalent and hence counted as one with respect to (37). For this reason, contrastive feature specifications have a greater impact on similarity than do redundant features, because adding a redundant feature to a definition does not result in a new, distinct natural class. Consider the Bumo Izon inventory in (35). The partial feature matrix [–labial, +dorsal, –sonorant,

–continuant, +voice] exhaustively defines the (singleton) set {g}.[22] Adding [–constricted glottis] has no effect, since the extension remains the same, namely {g}. The same is not true for labials: the description [+labial, –dorsal, –sonorant, –continuant, +voice] defines the set {b, ɓ}, whereas adding [–constricted glottis] to this will results in a distinct (sub)set {b}. Both of these are natural classes that /b/ enters into, and because they are distinct, both get counted separately when computing the similarity of /b/ to any other consonant. In the case of /g/, a single natural class gets counted as against these two, because of the fact that [–constricted glottis] is redundant in /g/.

The problem is that the model in (37) makes exactly the wrong prediction for a case like Bumo Izon. A correspondence-based analysis of this language will have to assume that, from the point of view of the CORR-C↔C constraint hierarchy, a pair like [ɗ]-[g] counts as less similar than a pair like [ɗ]-[b], since the former are permitted to co-occur while the latter are not. But precisely because of the fact that the [–constricted glottis] specification is redundant in [g] but contrastive in [b], the calculated similarity of [ɗ]-[g] will be *greater* than that of [ɗ]-[b], based on the equation in (37). The same would be true for most sibilant harmony systems with inert [t, d]. Most similarity metrics, including the model in (37), will judge a pair like [t’] vs. [tʃ’] to be more similar than [z] vs. [tʃ’], contrary to what needs to be stipulated by means of the CORR-C↔C hierarchy.

Another point worth considering is that what seems to be crucial in determining inertness vs. participation in a given harmony system is the redundancy vs. contrastiveness of a segment’s specification *for the harmony feature*. In the correspondence-based analysis developed in this work (cf. Walker 2000a, c, 2001, Rose & Walker 2004), the designation of the harmony feature is encoded in terms of a high-ranked IDENT[F]-CC constraint, which effectively demands agreement in [F]. Such constraints are entirely independent of, and have no causal connection to, the similarity scales that happen to be defined by the ranking of CORR-C↔C constraints. For example, if it is indeed true that in the phonological grammar of Ngizim a homorganic sonorant-stop pair like [t]-[r] counts as less similar (i.e. is subject to a lower-ranked CORR-C↔C constraint) than a heterorganic fricative-stop pair like [k]-[z] does, then this is in principle unrelated to the fact that Ngizim also *happens* to exhibit voicing harmony (between sufficiently similar segments) due to a high-ranked $^{\rightarrow}$IDENT[+voice]-CC constraint.

It would seem more fruitful to encode the contrast-sensitivity in a more direct fashion, rather than have it be mediated by similarity in such a stipulative manner. Furthermore, it would be logical to build this sensitivity into the harmony-enforcing ‘agreement’ constraints themselves (IDENT[F]-CC), since these are the ones that explicitly mention the feature whose contrastive vs. redundant status is so important. How exactly this should be done is left to future research (though see §5.3.3 for related issues). To some extent, this would be analogous to the analysis of Arabic OCP[Place] restrictions by Frisch et al. (2004). In that case, the

[22] Here the major-place features are treated as binary ([±labial], etc.) so as to have an easy way of defining labials and velars as distinct from labial-velars, but nothing hinges on this particular formulation.

sets corresponding to different values for [Place] were examined separately ([labial], [coronal], etc.) and similarity values were computed for all segment pairs *within* each of those sets. For example, the way (37) was applied to a particular coronal-coronal pair like /s/ vs. /t/ was to count only the natural classes *of coronals* that either or both of these phonemes enter into. In other words, the similarity relations that OCP[Place] takes into account are ones which are modulated by [Place]. To adopt a similar strategy to the problems under consideration here, one would need to pick out the set of all consonants that are contrastively either [+F] or [–F], and then compute similarity values over that set. This would then provide the basis for true similarity effects, such as the dichotomy between homorganic and heterorganic stop pairs in Ndebele and Zulu laryngeal harmony (§5.1.3) or the [Place]-sensitivity of Ngbaka co-occurrence restrictions (§4.1.3).

Be that as it may, it cannot be said categorically that all consonant harmony is sensitive only to contrastive features, never to redundant ones. The most obvious counterexample is Nkore-Kiga, where sibilant harmony operates over what is otherwise an essentially allophonic distinction (see §5.1.2). Another suggestive example is coronal harmony in Anywa (Reh 1996). As mentioned in §2.4.1.2 above (see also Rose & Walker 2004, Mackenzie 2005), Anywa appears to be an exception to the generalization that harmony only affects those consonants that are contrastively dental or alveolar, with redundantly alveolar consonants being neutral. In Anywa, like in certain related languages (e.g., Alur, Luo), there is no phonemic dental vs. alveolar contrast in nasals. Despite this fact, /n/ is realized as dental [n̪] in roots containing a (contrastively) dental stop ([n̪ùd̪ò] 'lick (sugar)' vs. [núːdó] 'press down'). In other words, /n/ fully participates in the [±distributed] harmony; in this respect, Anywa is unlike Alur and Luo, where /n/ is consistently [n] in such roots.

Rose & Walker (2004) take Anywa to be a clear counterexample against the notion that consonant harmony always involves contrastive features. However, while it is true that the dentality of [n̪] is always predictable in Anywa, there are other sources of [n̪] than coronal harmony, such as an underlyingly dental stop (by way of the kinds of root-final consonant 'mutations' described in §2.4.1.2 and §5.2). As a result, [n̪] does occur in surface forms in which there is no dental consonant nearby, and hence no obvious contextual source for the dentality of the nasal. For example, [pòːn̪ːò] 'become smooth' is derived from the root /pɔ̀ːd̪/ 'be smooth'. True, the dentality of [n̪] is *predictable* even in such cases, but only on the basis of knowledge of morphological relationships among word-forms. In fact, the same can be said about the [s] vs. [ʃ] distinction in Nkore-Kiga (§5.1.2); recall that /S/ is realized as [s] before an underlying /i/ even when that /i/ is not realized on the surface, such as the causative /-i/ in /…S-i-a/ → […sa]. This means that the predictable distribution of [s] vs. [ʃ] is not directly evident from surface phonotactics alone (since […sa…] does occur, alongside […ʃa…]), but rather presupposes a certain amount of morphological analysis. For this reason, the Anywa [n] vs. [n̪] and Nkore-Kiga [s] vs. [ʃ] distinctions would count as contrastive ('phonemic' as opposed to 'allophonic') from the traditionalist standpoint of classical phonemics. Whether such complications are relevant in accounting for the harmony patterns of these languages will be left as a question for future research, as will the broader issue of how the ‘contrastiveness’ notion might be formalized (and referenced in constraint definitions) within an output-oriented framework like Optimality Theory.

5.3.3. Featural Asymmetries and the CORR-C↔C vs. →IDENT[F]-CC Distinction

We saw above, in the discussion of contrastiveness vs. redundancy of [±F] specifications, that there may be some reason to reconsider the division of labor between CORR-C↔C and IDENT[F]-CC constraints, building sensitivity to such factors into the latter rather than the former. There are other, more direct reasons why one might want to shift some of the labor from the CORR-C↔C constraint hierarchy over to the IDENT[F]-CC constraints. In the extreme case, one might go so far as doing away with the former altogether. The crucial evidence comes from Nkore-Kiga sibilant harmony. In this case, the problem does not have to do with contrastiveness, but with how the scaling of potential trigger-target pairs by relative similarity and proximity is achieved in the analysis. When the full range of details are considered, the Nkore-Kiga case poses a problem for the analysis, and might be taken to suggest that the reference to relative similarity and proximity be built directly into the IDENT[F]-CC constraints, rather than by means of a hierarchy of separate CORR-C↔C constraints.

As we saw in §5.1.2 above, Nkore-Kiga has anticipatory sibilant harmony between [s, z] and [ʃ, ʒ], such that co-occurring sibilants are forced to agree in [±anterior], the rightmost one determining whether the surface feature value of both sibilants is [+anterior] or [–anterior]. This was analyzed as a featurally symmetric (‘double-value’) harmony system, in the sense that both →IDENT[+ant]-CC and →IDENT[–ant]-CC are undominated. The analysis laid out in §5.1.2 was based on a slightly idealized picture of Nkore-Kiga sibilant harmony. This simplified state of affairs does obtain when the two sibilants agree in voicing ([s] vs. [ʃ]) and are in adjacent syllables—separated, in effect, by nothing more than a vowel—that is, in the context [… S_XV.S_XV…] In such contexts we do indeed find [ʃ…ʃ] and [s…s] instead of otherwise expected [s…ʃ] and [ʃ…s], respectively, just as described and illustrated in §5.1.2.

However, when the two sibilants disagree in voicing and/or are separated by a greater distance, the pattern is slightly different. The directionality is unchanged, proceeding from right to left, but here the sibilant harmony is a featurally asymmetric (‘single-value’) system, such that only an [–anterior] sibilant triggers assimilation in the preceding sibilant. In other words, under these circumstances of *decreased* trigger-target similarity or proximity, a [s] or [z] will still assimilate to a following [ʃ, ʒ], but a [ʃ] or [ʒ] will not undergo assimilation to a following [s, z] (or at least not obligatorily so). This is illustrated in (38)–(39) below. In the forms in (38a) (all of which happen to be frozen causatives), the [ʃ…s] pair is in non-adjacent syllables and harmony fails to apply. In (38b), the two sibilants are in adjacent syllables, but they differ in voicing; again, harmony does not apply. As before, all data are drawn from Taylor (1959); recall that the forms in Taylor’s dictionary are almost exclusively from Kiga rather than Nkore.

(38) Nkore-Kiga sibilant harmony: emergence of [–anterior] 'dominance'

a. No harmony in [ʃV.CV.sV] sequences

-ʃomesa	/-Som-iS-i-a/	'teach'	([-ʃoma] 'read')
-ʃáːgisa	/-Sáːg-iS-i-a/	'make profit'	([-ʃáːga] 'be plenty, leftover')
-ʃuŋgisa	/-Suŋg-iS-i-a/	'tease'	([-ʃuŋga] 'flatter')
-ʃambisa	/-Samb-iS-i-a/	'go sour'	([-ʃamba] 'get dry; kick')[23]

b. No harmony in [ʃV(n).zV] sequences

-ʃanzire	/-SanZ-ire/	'spread out (perf.)'	([-ʃanʒa] 'spread out')
-ʃáːzja	/-Sáːg-i-a/	'bully; leave over'	
aka-ʃúzi	/-SúZi/	'bug'	
omw-eʃezi	/-eSeZi/	'cattle-waterer'	

Hyman (1999b) conducted an automated search of a computerized version of Taylor (1959) incorporated into the *Comparative Bantu Online Dictionary (CBOLD)* lexicographic database (http://linguistics.berkeley.edu/CBOLD), looking for stems with sibilants in C_1 and C_2 position. The resulting counts are shown in (39a–b). Corresponding results for [s] and [ʃ] (in either order) in C_1 and C_3 position are shown in (39c).

(39) Sibilant harmony patterns in Nkore-Kiga stems (Hyman 1999b)

a. C_1 vs. C_2: harmony between sibilants that agree in voicing:

Sequence	*Count*	*Sequence*	*Count*
ʃ…ʃ	78	ʒ…ʒ	34
s…s	67	z…z	22
ʃ…s	0	ʒ…z	(2)
s…ʃ	0	z…ʒ	0

b. C_1 vs. C_2: harmony between sibilants that disagree in voicing:[24]

Sequence	*Count*	
ʃ…ʒ	40	
s…z	14	
ʃ…z	**38**	**← disharmony allowed**
s…ʒ	0	

[23] The forms [omu-sambisi] 'sour milk' and [-sámbisiriwa] 'be in a rage', which are likely to derive from the same verb root /-Samb-/, do show harmony.

[24] Stems with a voiced sibilant as C_1 and a voiceless one as C_2 simply do not occur; hence the only combinations considered here consist of [s, ʃ] as C_1 and [z, ʒ] as C_2.

c. C_1 vs. C_3: long-distance sibilant harmony (non-adjacent syllables)

Sequence	*Count*	
ʃ…ʃ	25	
s…s	13	
ʃ…s	**13**	**← disharmony allowed**
s…ʃ	0	

The similarity-based asymmetry between (39a) and (39b), and the proximity-based asymmetry between (39a) and (39c), fits the general pattern, well established in the typology of consonant harmony systems laid out in this work, that the tendency for harmony grows weaker the less similar and/or more distant the two consonants are. The harmony in (39a) is 'stronger' than that observed in (39b) or (39c), in that it involves assimilation to [+anterior] as well, rather than to [–anterior] alone. The particular way in which this combined similarity and proximity effect is manifested in Nkore-Kiga is unusual, and leads to an intriguing problem for the analytical framework that has been developed here.

At the heart of the problem is the observation that the factors of trigger-target similarity and proximity are only relevant for [+anterior] harmony, not [–anterior] harmony. Assimilation to a following [–ant] sibilant is enforced regardless of similarity and proximity, whereas assimilation to a following [+ant] sibilant breaks down (i.e. is blocked, or never triggered in the first place) if the consonants in question are insufficiently similar or too far apart, as in (39b–c). The mere fact that [–ant] is a 'stronger' harmony trigger than [+ant] is in itself not a problem. We can simply infer from this that a ranking like →IDENT[–ant]-CC >> X >> →IDENT[+ant]-CC holds (where X is some constraint that is able to cancel out [+ant] harmony but which cannot interfere with the higher-ranked demand for [–ant] harmony). The problem lies deeper than this, however. Aside from the problem of identifying what sort of constraint X might be, we crucially need some way of explaining how it is that X interferes with →IDENT[+ant]-CC *only* under those circumstances where the two corresponding consonants in the [… C_X … C_X …] sequence are *either* placed relatively far apart (in non-adjacent syllables) *or* somewhat dissimilar (having mismatched [±voice] specifications).

It is here that the division of labor between CORR-C↔C and IDENT[F]-CC becomes a hindrance. In the analysis of consonant harmony as agreement by correspondence (ABC), it is only the former that are parameterized with respect to relative similarity and/or proximity. For example, CORR-[ant] and CORR-[ant, voi] form part of the similarity hierarchy: CORR-[ant] >> CORR-[ant, voi]. The lower-ranked CORR-[ant, voi] demands that any and all pairs of sibilant fricatives from the set [s, ʃ, z, ʒ] (those differing at most in [±anterior] and [±voice]) must stand in a $C_1 \leftarrow C_2$ correspondence relation. Higher-ranked CORR-[ant] makes the same demand of pairs drawn from either of the subsets [s, ʃ] and [z, ʒ] (sibilant pairs with matching [±voice] values). At first glance, it would seem that the (39a) vs. (39b) asymmetry—the fact that harmony is enforced in [ʃ…s] but not in [ʃ…z]—could be due to the differential ranking of CORR-[ant] and CORR-[ant, voi]. Since the surface distribution of [s] vs. [ʃ] is governed by the constraint ranking →NO[ʃi] >> *[s] (>> IDENT[±ant]-IO), the logical assumption would be that the appropriate ranking is then { →IDENT[+ant]-CC, CORR-[ant] } >> →NO[ʃi] >> *[s] >> CORR-[ant, voi]. But while this generates the right result for [–ant]…[+ant] sequences (harmony in more similar pairs, no harmony in less similar pairs), it runs aground when it comes to [+anterior]…[–anterior] pairs, where harmony is enforced regardless of similarity. The fact that harmony does apply in [s…ʒ] sequences no less than in [s…ʃ] (in that both are repaired/avoided in favor of [ʃ…ʒ] and [ʃ…ʃ], respectively) requires that the constraint CORR-[ant, voi] outrank →NO[ʃi]. In other words, there is an irreconcilable ranking paradox. The only constraints that are able to distinguish between the [–anterior]…[+anterior] and [+anterior]…[–anterior] scenarios are the IDENT[F]-CC constraints: they are governed by →IDENT[–ant]-CC and →IDENT[+ant]-CC, respectively. But IDENT[F]-CC constraints are not sensitive to similarity, and (39a) requires that →IDENT[–ant]-CC and →IDENT[+ant]-CC both be high-ranked. Only the CORR-C↔C constraints reference similarity, and these do not distinguish between [–F]…[+F] and [+F]…[–F]. The exact same dilemma applies when we consider the lack of [+anterior] harmony in long-distance [s…C…ʃ] sequences (39c). The failure of such harmony could only suggest low-ranked →IDENT[+ant]-CC, which (39a) demands be ranked high.

It has been assumed here that CORR-C↔C constraints are *symmetric*: if a sequence X…Y falls under a given CORR-C↔C constraint, so does Y…X. On this assumption, if correspondence is required in a [s…ʒ] sequence, it is required equally strongly in [ʃ…z]. This assumption, combined with the fact that agreement in any and all [–ant]…[+ant] sequences (of CC-corresponding consonants) is governed by a single constraint (→IDENT[+ant]-CC), means that it is impossible in principle to require agreement in [s…ʒ] and in [ʃ…s] but not in [ʃ…z]. Perhaps the symmetry assumption should be abandoned, such that correspondence in [s…ʒ] and [ʃ…z] sequences is governed by separate constraints, which we might call CORR-Š↔Z and CORR-S↔Ž, respectively. The (39a) vs. (39b) asymmetry could then be captured if we assume, as before, that both →IDENT[–ant]-CC and →IDENT[+ant]-CC are undominated, but that the ranking CORR-S↔Ž >> →NO[ʃi] >> *[s] >> CORR-Š↔Z holds in Nkore-Kiga. Similarly, the unbounded version of CORR-[ant] (that is, the constraint CORR-$[\text{ant}]_{C\text{-}\infty\text{-}C}$) would need to be split into two constraints: a high-ranked one requiring correspondence in [s…(C)…ʃ] sequences and a low-ranked one doing the same for [ʃ…(C)…s] sequences.

There is something deeply unsatisfactory about this solution. We have now introduced two distinct ways of encoding the 'dominance' of one feature value over another (e.g. [αF] over [–αF]), which have nothing in common: ranking IDENT[αF]-CC over IDENT[–αF]-CC, on the one hand, and splitting each CORR-C↔C constraint into separate [–αF]…[αF] and [αF]…[–αF] versions. This is a blatant redundancy. Moreover, recall that the CORR-C↔C constraints do not themselves require agreement in [F], nor do they make any reference to *which* feature might be designated (by IDENT[F]-CC) as the harmony feature. A high-ranked constraint like CORR-[Place, cont, voi] requires all obstruent pairs to stand in correspondence (regardless of differences in place, manner or voicing), but is oblivious to whether the 'purpose' of this correspondence relation is to serve as a vehicle for transmitting voicing harmony

([F] = [±voice]), stricture harmony ([F] = [±continuant]) or even, at least in theory, 'place harmony' ([F] = [Place]). Returning to Nkore-Kiga, this means that if we are to split CORR-[ant, voi] into separate [–ant]…[+ant] and [+ant]…[–ant] versions, we have no reason to reject a similar split into separate [+voi]…[–voi] and [–voi]…[+voi] versions as well (CORR-Ž↔S and CORR-Z↔Š, as distinct from CORR-Š↔Z and CORR-S↔Ž). For that matter, why not go even further and posit four different CORR-[ant, voi] constraints, one requiring correspondence in [+ant, –voi]…[–ant, +voi] sequences, one in [–ant, –voi]…[+ant, +voi] ones, and so forth? It is hard to see where to draw the line in a principled way.

The problem would be easily solved if we instead took the (admittedly drastic) step of encoding trigger-target similarity and proximity thresholds directly in the agreement-driving →IDENT[F]-CC constraints. This would entail abandoning the CORR-C↔C constraints altogether as independent constructs—and, along with them, the very notion of CC correspondence. Since we would then no longer be dealing with agreement under *correspondence*, IDENT[F] would become a somewhat inappropriate label. Directionality will still need to be built in, in order to account for the default nature of anticipatory (regressive, right-to-left) harmony; ANTICIPATE might thus be a suitable constraint name. A tentative definition of such a constraint is given in (40). This definition also attempts to capture the role of contrastiveness discussed in §5.3.2 above.

(40) →ANTICIPATE[αF]

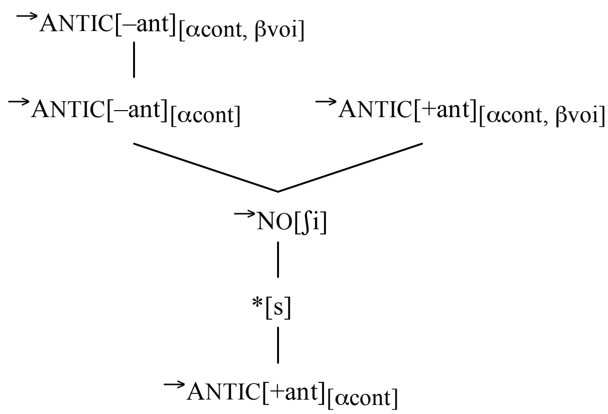
Let $C_1 \ldots C_2$ be an output sequence of consonants. If C_2 is contrastively [αF], then C_1 must not be contrastively [$-\alpha$F].

Candidate x' is preferred over candidate x ($x' \succ x$) iff x' is exactly like x except that at least one target consonant (a C_1 that is [$-\alpha$F]) has been replaced by its unmarked [αF] counterpart.

This constraint family would take over the function of the CORR-C↔C and →IDENT[αF]-CC constraints Just as the previous analysis captures similarity and proximity effects by scaling CORR-C↔C into a hierarchy, the same would be true of →ANTICIPATE[αF] constraints. For example, →ANTICIPATE[+anterior] would be split into the pair →ANTICIPATE[+ant]$_{\text{C-V-C}}$ >> →ANTICIPATE[+ant]$_{\text{C-}\infty\text{-C}}$, to yield a proximity hierarchy. The former constraint would demand harmony in […ʃVs…] sequences, the latter in […ʃVs…] and […ʃVCVs…] alike. A similarity hierarchy can be established analogously, e.g. →ANTICIPATE[+ant]$_{[\alpha\text{cont}, \beta\text{voi}]}$ >> →ANTICIPATE[+ant]$_{[\alpha\text{cont}]}$; the former requires harmony in […ʃVs…] and […ʒVz…] sequences, the latter also in […ʃVz…] and […ʒVs…].

Drastic though it may be, this move would render the Nkore-Kiga problem tractable. For example, to account for the fact that in /…SVS…/ contexts, both [+anterior] and [–anterior] harmony hold, whereas in /…SVCVS…/ contexts we see only [–anterior] harmony, all we need is to assume the ranking in (41):

(41) Nkore-Kiga similarity effect with →ANTICIPATE[αF] constraints:



The →ANTICIPATE[–ant] constraints enforce regressive [–anterior] harmony (e.g., favoring [ʃ…ʒ] over [s…ʒ]). These dominate the allophonic-distribution constraint pair →NO[ʃi] >> *[s] irrespective of whether the two sibilants agree in voicing. For the →ANTICIPATE[+ant] constraints, which are responsible for triggering regressive [+anterior] harmony, the same is not true. Here only the version of the constraint that has the higher similarity threshold (→ANTICIPATE[+ant]$_{[\alpha\text{cont}, \beta\text{voi}]}$) dominates →NO[ʃi] >> *[s], not the less stringent version (→ANTICIPATE[+ant]$_{[\alpha\text{cont}]}$). As a result, same-voicing /…SVS…/ contexts display [–ant] and [+ant] harmony (39a), whereas different-voicing /…SVZ…/ contexts exhibit only [–ant] harmony (39b).

It remains to be seen whether the alternative correspondence-free approach sketched here (which has much in common with the anti-disagreement constraints of Pulleyblank 2002) is a viable alternative to the ABC model. It is certainly a 'leaner' model, and while it is somewhat less powerful than the correspondence-based approach—in that the ABC model allows for a variety of constraint interaction effects that would no longer be predicted—this is arguably not a disadvantage, since various patterns predicted by ABC are not empirically supported. For example, since all CC correspondence operates in the same dimension, this predicts the possibility of unattested 'crossover' effects in languages in which two separate harmonies co-exist—for example, agreement in [±F] in one class of segments, and agreement in [±G] in some other (possibly overlapping) class of segments. Since CORR-C↔C constraints are oblivious to the identity of the harmony feature, all CC-correspondents are equivalent: if a given consonant pair is sufficiently similar to enter into correspondence 'for the purpose of' agreement in [±F], it will automatically be considered for agreement in [±G] or [±H] as well. In the same vein, Hansson (2007a) points out certain odd and likewise unattested opacity patterns (blocking by intervening segments) that arise as a direct consequence of the ABC model. In light of these considerations, in addition to the problem of Nkore-Kiga sibilant harmony discussed above, it seems that the elimination of CC correspondence in favor of simple agreement constraints is at least an option worth exploring.

6. CONSONANT HARMONY AND SPEECH PLANNING: EVIDENCE FROM PALATAL BIAS EFFECTS

One of the central claims made in this work is that consonant harmony is to be construed as featural *agreement* at-a-distance, rather than local *spreading* of features or articulatory gestures between segments that are adjacent at the root-node tier.[1] Moreover, it has been suggested that, as a phonological phenomenon, this type of agreement has its roots (diachronic and/or synchronic) in the domain of speech planning—more specifically, phonological encoding for speech production. Under this view, consonant harmony interactions are motivated, or at least facilitated, by trigger-target similarity: the more similar two co-occurring consonants are, the more likely it is that they will be forced to agree in some feature. (Many co-occurrence restrictions of a *dissimilatory* nature can likewise be linked to speech planning and processing factors; Frisch 1996, 2004, Frisch et al. 2004.) In a sense, then, the systematic consonant harmony patterns that are observed in many languages constitute the phonologized counterpart of on-line processing phenomena such as slips of the tongue.

This chapter reviews the evidence for the position that consonant harmony is intimately tied to the psycholinguistic domain of language processing. A number of parallels between consonant harmony processes and speech errors are discussed. The main focus of the chapter is on one such parallel in particular, one which had not been documented in the phonological literature prior to Hansson (2001a, 2001b). This concerns the so-called Palatal Bias effect, which has been robustly documented in speech error studies: in phonological slips of the tongue, 'palatals' (postalveolars) like /ʃ/ or /tʃ/ intrude upon alveolars like /s/ or /t/ far more frequently than vice versa. As demonstrated in this chapter, the exact same asymmetry shapes the cross-linguistic typology of coronal harmony systems.

As supportive evidence for the agreement-based analysis of consonant harmony, the existence of Palatal Bias effects in coronal harmony systems is important. One reason is that coronal harmony is by far the most widely attested type of consonant harmony. Indeed, coronal harmony, especially sibilant harmony, can be considered the 'canonical' instantiation of consonant harmony. More importantly, however, coronal harmony systems and their phonetic-

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[1] An earlier and much-condensed version of this chapter appeared as Hansson (2001a).

phonological properties have played a central role in works arguing for the analysis of consonant harmony in terms of strictly-local spreading of articulatory gestures or their featural counterparts (Gafos 1999). Since the agreement analysis developed in chapters 4 and 5 was presented as an alternative to such spreading-based analyses, any evidence for the agreement analysis that revolves around *coronal* harmony as such carries considerable weight. Taken in conjunction with other parallelisms between speech errors and consonant harmony patterns, the existence of Palatal Bias effects in both domains provides strong evidence for the view that consonant harmony involves long-distance agreement, and that it is rooted in the domain of speech planning and processing.

The chapter is organized as follows. Section §6.1 summarizes various types of evidence showing that consonant harmony processes share significant affinities with slips of the tongue. The Palatal Bias phenomenon as it pertains to phonological speech errors is introduced in §6.2. In §6.3 we see how the same Palatal Bias manifests itself in the cross-linguistic typology of sibilant harmony systems of the relevant kind. The same is shown in §6.4 for those rare coronal harmony cases that involve a coronal stop vs. affricate contrast. The findings are summarized in §6.5.

6.1. Consonant Harmony and Speech Errors: A Review of the Evidence

Elsewhere in this study, several aspects of consonant harmony systems and their cross-linguistic typology have been described which are mirrored in the psycholinguistic domain of speech errors. In subsequent sections of this chapter we will encounter an especially striking parallel of this kind: the appearance of so-called Palatal Bias effects in coronal harmony systems of different kinds. Before introducing that particular phenomenon, it is useful to summarize those aspects of consonant harmony that have already been described in previous chapters and which bear on the relationship between consonant harmony and phonological slips of the tongue. These are: (a) similarity effects; (b) directionality effects; (c) transparency of intervening segments.

6.1.1. Similarity Effects

It is a well documented fact that speech errors are highly sensitive to the relative similarity of the elements involved. Segments that share a large number of properties are more likely to interact in slips of the tongue than are segments that have fewer properties in common (Nooteboom 1969, MacKay 1970, Fromkin 1971, Shattuck-Hufnagel & Klatt 1979, Frisch 1996). In neural network models of language production (e.g. Stemberger 1985, Dell 1986), this correlation falls out from spreading activation. When two co-occurring consonants share a large number of features, there is extensive overlap in the neurons activated for C_1 and C_2. The greater the overlap, the greater the potential for interference effects between the two consonants.

As for consonant harmony, it is evident from the overview in chapter 2, as well as some of the cases analyzed in chapters 4 and 5, that similarity effects abound in the typology of consonant harmony systems. Eligibility as a trigger-target pair frequently presupposes that the two consonants already agree in one or more features. Alternatively, harmony between less similar consonants may be subject to special limitations or restrictions that do not hold for harmony between more similar consonants. Similarity effects of precisely this kind are in large part what originally motivated the analysis of certain types of consonant harmony as featural agreement—rather than as feature spreading—in the agreement by correspondence (ABC) model, for example in Walker's (2000a, 2000c, 2001) studies of certain laryngeal and nasal consonant harmony systems (see Rose & Walker 2004). Importantly, similarity effects are equally characteristic of *coronal* harmony, the phenomenon that has been argued at length to involve spreading by Gafos (1999), Ní Chiosáin & Padgett (1997) and others. As an example of such similarity effects, sibilant harmony is often limited to fricative-fricative and/or affricate-affricate pairs, leaving fricative-affricate combinations unaffected (Rwanda, Wanka Quechua). In addition to manner (stricture) differences, coronal harmony may also be sensitive to the laryngeal features of the trigger and target. For example, as detailed in §5.3.3 above, Nkore-Kiga sibilant harmony has a more limited effect on mixed-voicing sibilant pairs ([s…ʒ], [ʃ…z]) than on same-voicing pairs ([s…ʃ], [ʃ…s], [ʒ…z], [z…ʒ]).

Outside of coronal harmony, place and manner distinctions are often involved in similarity-based restrictions on consonant harmony. For example, laryngeal harmony (e.g. voicing harmony) is always confined to obstruent-obstruent pairs. It may be further limited to stop-stop pairs and/or to fricative-fricative pairs, without affecting stop-fricative pairs (Kera, Imdlawn Berber). Stricture harmony can be limited to homorganic obstruent pairs (Yabem). Laryngeal harmony is often limited to homorganic obstruent pairs as well (Ngbaka). Alternatively, laryngeal harmony may be subject to certain restrictions in the case of heterorganic pairs which do not apply when the consonants are homorganic (Ndebele, Zulu; see §2.4.7 and §5.1.3 above).

In sum, similarity is a major determinant of the likelihood of consonant-consonant interactions both in the psycholinguistic domain of language production (as evident from speech errors) and in the phonological domain of the long-distance assimilatory interactions referred to as consonant harmony. Though this parallel is hardly conclusive evidence in itself, it is nevertheless consistent with the hypothesis that consonant harmony interactions—both those which involve coronal-specific features/gestures and those based in other kinds of properties—has its roots in speech planning.

6.1.2. Directionality Effects

A second parallelism between consonant harmony and slips of the tongue lies in the directionality patterns these two phenomena exhibit. As discussed in §3.1 above, anticipatory (regressive, right-to-left) assimilation emerges in the typological survey as the predominant directionality of consonant harmony interactions, other things being equal. Anticipation thus appears to be the ‘default’ in consonant harmony, and this notion has been incorporated into the formal correspondence-based analysis as laid out in chapters 4 and 5.

Interestingly, the same directionality default has been observed to be characteristic of the harmony patterns that are very frequently found in child language. In her survey of consonant harmony in child language, Vihman (1978) notes that the reported data predominantly show anticipatory assimilation. Of all the documented examples of consonant harmony in the corpus surveyed by Vihman, 67% involved anticipation. The same bias remained when the data was broken down further. Looking at individual cases, for example, anticipations constituted 79% of the harmony examples in Amahl’s speech, whereas in Virve’s speech the relevant figure was 69%. (These two children accounted for nearly half of the harmony forms in Vihman’s corpus.) For the remaining group of children, 61% of the harmony assimilations were anticipatory.

More importantly, anticipatory interactions have also been shown to have a privileged status in speech errors. This was briefly discussed in §4.2.1.2 above, but the relevant findings are repeated here for convenience. Note first that, when translated into the perspective of phonological encoding for speech production, the prevalence of anticipatory over perseveratory assimilation in consonant harmony processes (whether in adult or child language) can be formulated as follows:

(1) Anticipation as default: the planning perspective

In the production of a phonological output string containing several consonants ([…C_{n-1}…C_n …C_{n+1}…]), the realization of a given consonant (C_n) tends to be influenced by an upcoming consonant which is being planned (C_{n+1}), rather than by one which has already been produced (C_{n-1}).

The formulation in (1) takes into account the fact that, at the time when the production of the current element is being executed, the production of upcoming elements is already being planned. The basic functional requirements of any serial-order production mechanism, including the one responsible for language production, are summarized by Dell et al. (1997) as follows:

(2) Functional requirements of the language production mechanism (Dell et al. 1997):

a. Turn-on function: The system must activate the *present*.

b. Turn-off function: The system must deactivate the *past*.

c. Prime function: The system must prepare to activate the *future*.

In most language production models, the prime function in (2c) is implemented by activating a *plan representation* of some kind Activation of this plan causes anticipatory activation of upcoming elements (the ‘future’), which may in turn interfere with the realization of the current element (the ‘present’). With respect to the functions in (2), anticipatory effects in speech errors thus result from (2c) interfering with the basic turn-on function in (2a). By contrast, perseveratory effects would have to arise from *not* carrying out the turn-off function in (2b) efficiently enough: activation from a 'past' element lingers on and interferes with the execution of the 'present' element.

As discussed by Schwartz et al. (1994) and Dell et al. (1997), anticipatory interference in language production is considerably more common than perseveratory interference, other things being equal. Under normal circumstances, anticipatory speech errors typically outweigh perseveratory errors by a ratio of 2:1 or even 3:1, a fact which Dell et al. (1997) refer to as the *general anticipatory effect*. This appears to be the normal state of affairs in a relatively error-free production system: 'when the language-production system is working well, it looks to the future and does not dwell on the past' (Dell et al. 1997:123). Unlike anticipatory errors, perseveratory errors appear to be more characteristic of relatively more dysfunctional states of the production system (as reflected in higher overall error rates). In general, the proportion of perseveratory errors seems to be strongly correlated with overall error rate. The findings are as summarized in (3).

(3) Correlation of perseveratory errors with dysfunctional (error-prone) states:

a. Practice effect:
When producing unfamiliar and difficult phrases, practice reduces the overall error rate and also greatly lowers the proportion of perseveratory errors as compared to anticipatory ones (Schwartz et al. 1994, Dell et al. 1997).

b. Speech rate effect:
The ratio of perseveratory errors to anticipatory errors increases with increased speech rate, that is, as available time for speaking decreases (Dell 1990, Dell et al. 1997).

c. Aphasic speech:
The speech of many aphasic patients is characterized by a much higher proportion of perseveratory errors than non-aphasic speech (Schwartz et al. 1994).

d. Children's speech:
The proportion of perseveratory errors over anticipatory ones is considerably higher in the speech of children, especially younger children, than it is in adult speech (Stemberger 1989).

To sum up, the generalization seems to be that other things being equal, slips of the tongue are far more likely to involve anticipation (regressive interference) than perseveration (progressive interference). The default status of anticipatory interference is ultimately due to the nature of the serial-order mechanism responsible for language production: a segment which is currently being produced may be influenced by an upcoming segment that is simultaneously being planned—and thus activated, in anticipation of its production (for further discussion, see Dell et al. 1997). This is entirely parallel to the directionality asymmetry observed in the typology of consonant harmony systems. In consonant harmony, anticipation is the norm, whereas perseveratory assimilation emerges as a by-product of other factors, primarily sensitivity to morphological constituency, where the directionality of assimilation is more properly characterized as 'inside-out' than 'left-to-right'. The parallelism that holds between consonant harmony and speech errors with regard to directionality strongly supports the view that the former has its roots in the domain of speech-production planning.

6.1.3. Transparency of Intervening Material

In addition to similarity effects and directionality asymmetries, a third aspect to consider is transparency of the segmental material intervening between the trigger and target consonants. As explained in §1.2.3 and §4.1.1 above, the analysis of consonant harmony as strictly-local spreading (Gafos 1999 [1996], Ní Chiosáin & Padgett 1997) does not allow for genuine transparency. In those cases which appear to involve long-distance assimilation, such as Ineseño Chumash /ha-s-xintila-waʃ/ → [haʃxintilawaʃ] 'his former Indian name', the claim is that the spreading articulatory gesture that is responsible for the /s/ → [ʃ] change in fact permeates the vowels and consonants intervening between the two sibilants, including the nonsibilant coronals transcribed as [n], [t], [l].[2] These non-sibilant segments are thus assumed to be phonetically co-articulated with the spreading gesture, though this has little or no acoustic-auditory effect and is therefore not noted in the transcriptions given in descriptive sources. The same is taken to be true of all coronal harmony systems. However, the evidence adduced in support of this hypothesis has been almost exclusively conjectural: the mere observation that the gestures involved in coronal-harmony interactions *might* conceivably be transmitted by way of intervening segments.

As argued at length in §3.2 above, the local-spreading hypothesis makes the prediction that segmental opacity effects are expected to occur in at least some coronal harmony systems, resulting from the incompatibility of particular segment types (especially other coronals) with the spreading gesture. Until recently, no such cases had been attested: in striking contrast to vowel harmony and what has here been referred to as 'vowel-consonant harmony' (e.g. nasalization spreading), the typology of consonant harmony systems seems conspicuously devoid of cases in which a subset of potential interveners are opaque, blocking the trigger-target interaction.[3] As discussed in §3.2.2.2, opacity effects have since been discovered in

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[2] Moreover, though this aspect of spreading analyses is rarely discussed explicitly, the spreading tongue-tip/blade gesture is implicitly claimed to permeate the [ha…] sequence on the opposite side of the affected /s/ as well. This is because the constraint responsible for triggering spreading is formalized as a demand for alignment of the feature/gesture in question to the left edge of the *word* (or association with every segment intervening between the triggering [ʃ] and that word-edge).

[3] A well-known case which is usually treated as an example of coronal harmony, and which does display segmental opacity effects, is Vedic Sanskrit *n*-retroflexion (Steriade 1987, Gafos

Rwanda sibilant harmony (Walker & Mpiranya 2005, Mpiranya & Walker 2005): harmony is optionally enforced between sibilant fricatives in non-adjacent syllables (/-sákuz-/ + /-i-e/ → [-sákuz̧e] ~ [-şákuz̧e] 'shout (perf.)'), but not if a non-sibilant coronal intervenes (/-síːtaːz-/ + /-i-e/ → [-síːtaːz̧e], *[-şíːtaːz̧e] 'make stub (perf.)'). Furthermore, articulatory investigation has confirmed that the tongue-tip raising gesture does indeed carry through the intervening segments in a case like [-şákuz̧e] (Walker et al. 2008).

From these findings, Walker & Mpiranya (2005) conclude that the apparent sibilant harmony in Rwanda is not due to (similarity-driven) agreement by correspondence but rather to a constraint SPREAD-L(retroflex) which, while triggered by sibilant fricatives ([–sonorant, +continuant] segments), does not in any way single out sibilant fricatives as *targets* of spreading. In other words, their suggestion is that the Rwanda case is fundamentally different in kind—at least with respect to its synchronic phonological aspects—from the consonant harmony phenomena surveyed in this work and in Rose & Walker (2004). This conclusion is likely to be premature, however; upon closer inspection, it turns out that the ABC model does in fact predict the possibility of segmental opacity effects (Hansson 2007a, 2007b). In particular, local feature/gesture spreading, passing through intervening vowels and non-participating consonants, can emerge as the optimal strategy for satisfying a demand for long-distance agreement between corresponding consonants (Hansson 2007b). While this seriously complicates the diagnostic task of telling agreement-based interactions from ones that involves spreading for its own sake, Hansson (2007b) argues that, if anything, the articulatory data reported by Walker et al. (2008) are more compatible with an analysis in which local spreading occurs as a means to achieve long-distance agreement between a pair of sibilant fricatives.

Given that segmental opacity effects are not incompatible with an agreement interpretation of consonant harmony, the question instead becomes why opacity effects are so vanishingly rare in the typology of coronal harmony, in contrast to that of vowel harmony and 'vowel-consonant harmony'. Even more importantly, as discussed at length in §3.2.2.1, many *non*-coronal harmony systems display direct evidence for the genuine transparency of intervening vowels and consonants, such that an account in terms of strictly-local spreading is not tenable. This is trivially true of such phenomena as nasal consonant harmony, which does not result in the nasalization of intervening vowels and non-participating consonants (e.g. voiceless obstruents). But even in cases where the triggering consonant *does* phonetically affect immediately adjacent segments, such as neighboring vowels, there is often clear evidence that

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1996, Ní Chiosáin & Padgett 1997). As argued at length in §3.2.3 above, there are strong independent reasons to view the Sanskrit phenomenon as something entirely distinct from consonant harmony (see also Rose & Walker 2004). This particular phenomenon does indeed appear to involve spreading, and additionally displays a series of properties which are commonly found in vowel harmony and 'vowel-consonant harmony' systems, but are unattested or highly unusual for consonant harmony systems; segmental opacity is merely one of these. Hence Sanskrit does not constitute a counterexample to the near-absolute empirical generalization that consonant harmony systems do not display opacity effects.

the *harmony* effect it has on a non-adjacent target consonant is a genuine long-distance interaction, where intervening segments are 'skipped' rather than being 'permeated' by the harmony feature. One such case will here be repeated from section §3.2.2, to which the reader is referred for more detailed discussion of transparency issues.

In the dorsal consonant harmony found in some languages of the Totonacan family, the velar stops /k, k'/ become uvular when followed by a uvular stop (/q/ or /q'/) in the same word (see §2.4.2 above). In other words, underlying sequences like /k…q/ are harmonized to [q…q]. This phenomenon is documented by Watters (1988) for Tlachichilco Tepehua and MacKay (1999) for Misantla Totonac. In both cases, the harmony coexists with a local assimilatory effect—a pan-Totonacan and cross-linguistically very common process—whereby high vowels are lowered by a neighboring uvular stop. This is illustrated by forms such as the Tlachichilco Tepehua ones in (4), where /i, u/ are realized as [e, o] when immediately preceded or followed by /q/ or /q'/. (Note that in this particular language, underlying /q'/ normally surfaces as [ʔ] phonetically, as in the (4b) examples.)

(4) Tlachichilco Tepehua: vowel lowering next to uvulars (Watters 1988).

a.	/qin-t'uj/	→	[qen-t'uj]	'two (people)'
	/ʔaq(-)tʃuq/	→	[ʔaq-tʃoq]	'pot'
b.	/lak-tʃiq'i-j/	→	[laq-tʃeʔej]	'X shatters Y (perf.)'
	/tsuq'u/	→	[tsoʔo]	'bird'

This invites the possibility that dorsal harmony might be due to the very same kind of local interaction as that seen in (4). If this were the case, then the realization of an underlying sequence like /…kiCuq…/ as […qeCoq…] would involve the gesture responsible for the uvularity of /q/ (a retraction of the tongue root and/or tongue dorsum) spreading throughout the entire CVCVC sequence, affecting everything in its path.

However, words where the dorsal stops are spaced further apart clearly contradict this interpretation. They indicate instead that the /k…q/ → [q…q] assimilation seen in dorsal consonant harmony is a genuine long-distance interaction, in which the intervening segments do not act as 'mediators', passing the feature/gesture along. This is evident from forms like those in (5), where the crucially non-lowered vowels in the middle of a dorsal consonant harmony span are underlined.

(5) Tlachichilco Tepehua: non-lowered [i, u] within dorsal harmony span (Watters 1988)

a.	/lak-puːtiq'i-ni-j/	→	[laq-pu̲ːteʔe-ni-j]	'X recounted it to them'
b.	/ʔak-pitiq'i-j/	→	[ʔaq-pi̲teʔe-j]	'X folds it over'

Vowel lowering is a *local* process that applies only to vowels that are immediately adjacent to a uvular consonant. This lowering process is blocked by any intervening segment. For example, in both (5a) and (5b) the intervening [p] blocks the (progressive) lowering of a following high vowel in the sequences […qpuː…] and […qpi…]. The dorsal consonant harmony (i.e. uvularity agreement) that holds between the underlying velar and uvular stops, by contrast, is a *non-local* interaction, which does not itself affect intervening vowels and consonants.

In sum, on the question of whether intervening segments are active participants in consonant harmony, or whether they are instead ignored by the phonological constraints responsible for harmony interactions—and are thus entirely inert and transparent ('skipped over'), other things being equal—the evidence is overwhelmingly in favor of transparency. This is entirely in conformity with the ABC analysis of consonant harmony laid out in chapters 4 and 5 above (and in Rose & Walker 2004), since that analysis treats intervening vowels and consonants as irrelevant by-standers, as it were, which do not participate in the correspondence relations that serve as the vehicle for agreement. In the context of the present chapter, what is most relevant in this connection is the fact that feature/gesture spreading likewise appears not to be involved in phonological speech errors. The interaction of consonants in slips of the tongue does seem to be a genuine case of 'action at a distance'. Where the error in question is a matter of anticipation or perseveration, with a following or preceding consonant intruding in some way on the one currently being produced, intervening vowels and consonants are genuinely transparent. There is no evidence that they are 'permeated' by the articulatory (or other) properties of the intruding segment.

Again, this is trivially true in those cases where the substitutions involve a change in features such as [±nasal] (e.g., *mask math* for the word pair *bask math*), where the slip obviously does not result in the nasalization of intervening vowels and consonants. More importantly, the same is true of slips involving those phonological distinctions that form the basis of most coronal harmony systems, such as [s] vs. [ʃ]. This can be seen from data reported in articulatory studies of speech errors. In a study using electromyography (EMG), Mowrey & MacKay (1990) monitored single-motor-unit activity during the production of tongue twisters, including the familiar sequence *she sells seashells by the seashore*. Their EMG tracings of anomalous productions of this tongue twister phrase—that is, ones in which some degree of [ʃ]-related activity occurred on the initial /s/ of *seashells* and/or *seashore*—clearly show that spreading is not involved. The articulatory activity associated with /ʃ/, which 'intrudes' on /s/, does so in a non-local manner, in that it constitutes an independent burst of activity occurring solely on the target /s/, not on any of the nearby vowels and non-sibilant consonants.

The same can be concluded from data from kinematic studies that track articulatory movements during utterances exhibiting speech errors (Pouplier et al. 1999, Pouplier 2003, 2007, Goldstein et al. 2007). For example, Pouplier et al. (1999) found that in elicited utterances consisting of prolonged repetitions of phrases like *sop shop* at relatively fast speech rates, gestures associated with [ʃ] were often found to intrude on the production of [s] The articulatory tracings clearly show that the effect of [ʃ] on a nearby [s] is a matter of a separate gesture intruding on the target [s], not a single gesture being extended ('spread') from a triggering [ʃ] to the target [s]. This was true of both of the two [ʃ]-related gestures monitored in the study: lip protrusion, and raising of the front part of the tongue dorsum.

With respect to slips of the tongue, the findings are thus unequivocal. In anomalous productions like [ʃ]*op* [ʃ]*op* for intended [s]*op* [ʃ]*op*, or of [ʃ]*ea*[ʃ]*ore* for intended [s]*ea*[ʃ]*ore*, the gestures involved in the articulation of [ʃ] are repeated, not extended from one [ʃ] to the other. The claim made in this work is that we have reason to believe that the same is also true of the assimilatory interactions observed in phonological patterns of consonant harmony. These are a matter of agreement rather than spreading, and as such involve 'repetition' of phonological features and gestures, not their temporal extension throughout some domain.

6.2. Speech Error Corpora and the Palatal Bias

In a landmark study of phonological speech errors and their sensitivity (or lack thereof) to segmental markedness relations, Shattuck-Hufnagel & Klatt (1979) noted a curious asymmetry in how frequently certain segment types occurred as targets vs. intrusions in single-segment errors. (In an errorful utterance like *change the **p**irst part*, the /f/ of the intended word *first* is referred to as the target segment, whereas the /p/ that replaces it is the intrusion segment—in this case due to anticipation of the following word *part*.) What Shattuck-Hufnagel & Klatt (1979) discovered was the surprising fact that certain high-frequency alveolar consonants, in particular /s/ and /t/, are significantly more often targets than they are intrusions, whereas their lower-frequency 'palatal' counterparts /ʃ, tʃ/ are more often intrusions than they are targets. Note that throughout this chapter, segments of the latter type will be referred to as 'palatals', in keeping with common practice in the relevant literature, even though '(lamino-)postalveolars' would be a more accurate term.

Shattuck-Hufnagel & Klatt (1979) found this asymmetry to hold both in the MIT speech error corpus (see Garrett 1975) and in the UCLA corpus (Fromkin 1971). Moreover, a study of both corpora revealed that the asymmetric target vs. intrusion distribution of /s, t/ and that of /ʃ, tʃ/ are connected. The true generalization is that the alveolars tend to be *replaced by* the palatals significantly more often than vice versa. That is, errors involving substitutions like /s/ → [ʃ] are much more commonly found than ones involving /ʃ/ → [s]. This generalization is summarized in (6), illustrated with examples from Stemberger (1991).[4]

(6) Asymmetries in phonological speech errors with coronal obstruents

a. Palatal intruding on alveolar (frequent)

/s/ → [ʃ] *And **sh**o (= so) **sh**e just cashed it.*

/t/ → [tʃ] *Then we could just **ch**oss (= toss) out these **ch**ecks.*

b. Alveolar intruding on palatal (less frequent)

/ʃ/ → [s] *... **s**eventy percent to **s**ow—to show that it's not random.*

/tʃ/ → [t] *Rapa **T**ortilla **t**ips—chips.*

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[4] It so happens that the examples cited in (6b) both involve *perseveratory* errors, as compared to the anticipatory errors cited in (6a); this is purely accidental.

Shattuck-Hufnagel & Klatt (1979) refer to the asymmetry in (6) as being due to an as-yet-unexplained 'palatalization mechanism'. Stemberger (1991) uses the term Palatal Bias, which will be adopted here.

The error counts in table (7), extracted from a similar table from Shattuck-Hufnagel & Klatt (1979:47) show how the Palatal Bias is manifested in the MIT and UCLA speech error corpora. Alveolar/palatal pairs other than the ones cited here (e.g., /z/ vs. /ʒ/, /d/ vs. /dʒ/, etc.) are omitted for the reason that the incidence of such errors is too low to be able to show any significant asymmetry or lack thereof. The labels 'C1' and 'C2' are merely for reference and do not imply anything about the relative order of the target and the source of the intrusion.[5]

(7) Palatal Bias in speech error corpora (Shattuck-Hufnagel & Klatt 1979)

	MIT corpus		*UCLA corpus*	
C1 : C2	*C1 → C2*	*C2 → C1*	*C1 → C2*	*C2 → C1*
s : ʃ	68	33	32	9
s : tʃ	17	1	3	2
t : tʃ	14	4	3	1

Note that the fricative-affricate pair /s/-/tʃ/ is among those listed in (7). Errors involving this pair are hardly found at all in the UCLA corpus, but are not uncommon in the MIT corpus. Shattuck-Hufnagel & Klatt (1979:47, n. 2) note this discrepancy and comment that '[t]he difference between the MIT and UCLA corpus with respect to the s: č pair is large enough to suspect some sort of transcription bias in one or the other data set, making it all the harder to determine the exact form of any palatalization mechanism'. For this reason, the remainder of this section will focus on the pairs /s/-/ʃ/ and /t/-/tʃ/.

Since Shattuck-Hufnagel & Klatt (1979) made this discovery, the Palatal Bias has been reported in other speech error corpora as well, for example in that of Stemberger (1991). It has also been documented in languages other than English, such as in the German speech error corpus of Berg (1988). Bolozky (1978: 214) describes the very same asymmetry in Hebrew in the following manner:

> [I]n Hebrew, non-consecutive *š-s* or *š-z* sequences are hardly ever confused, whereas the opposite, i.e. the replacement of *s* by *š* in anticipation of another *š*, occurs quite often, primarily in casual speech and in child language.

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[5] In fact, in many of the errors the source cannot be identified—often because the utterance is aborted immediately after the error, so that the source of what might be an anticipatory error is impossible to determine. An error like /s/ → /ʃ/ thus simply indicates that a word containing /s/ (e.g. *sing* or *bus*) was uttered with [ʃ] instead of the correct [s].

Bolozky (1978) cites examples such as the slips [oʃek murʃe] for intended [osek murʃe] 'certified business owner' and [ʃar ʃalom] for the proper name [sar ʃalom], as well as the child-language form [ʃaʃa] 'Sasha (proper name)', and points out that forms like [ʃastom] 'valve' or [ʃazuf] 'sun-tanned' typically do not result in slips like [sastom], [zazuf].

All the data cited thus far have been drawn from speech error corpora, which consist of collections of naturally occurring slips of the tongue. Stemberger (1991) also found the Palatal Bias to be reliably present in errors that were experimentally induced using the SLIPS paradigm (Motley & Baars 1975, Motley et al. 1983). In his experiment, Stemberger (1991) found 65 errors where an alveolar was replaced by a palatal, as opposed to a mere 38 errors in which a palatal was replaced by an alveolar. The difference was most striking for the pairs s-ʃ (22 'palatalizations' vs. 8 'depalatalizations') and t-tʃ (14 vs. 1). In short, the existence of a Palatal Bias has been robustly confirmed by experimental methods.[6]

It is also possible to interpret results reported in articulatory studies of gradient speech errors as corroborating the Palatal Bias, although the data are not always straightforward to interpret from this perspective. The EMG study of Mowrey & MacKay (1990) was mentioned earlier in this chapter. Among the tongue twisters used in that study was the familiar sentence *She sells seashells on the seashore*. In all of the s/ʃ errors that Mowrey & MacKay report, the error—be it gradient or categorical—involves some degree of motor activity associated with [ʃ] intruding on a nearby [s], rather than vice versa. In a kinematic EMMA study, Pouplier et al. (1999) examined articulatory movement data in order to observe errors at the level of individual gestures. Some of the stimuli used in this kinematic study involved alternating sequences with /s/ and /ʃ/ (*sip ship*, *sop shop* or *bass bash*, each repeated continuously for 10 seconds). Out of the 18 instances of s/ʃ errors that appeared in the data, 16 were of the type /s/ → [ʃ]. In all of these, some degree of gestural activity associated with the /ʃ/ intruded on the nearby /s/. (The relevant gestures were raising of the front part of the tongue dorsum, as well as lip protrusion.) In sum, these instrumental studies of experimentally induced speech errors seem to replicate the Palatal Bias asymmetry documented in earlier studies.

As noted in the cross-linguistic survey of chapter 2, coronal harmony is by far the most widely attested type of consonant harmony in the world's languages. More specifically, the predominant variety is coronal *sibilant* harmony, which is found in a great number of language families spanning different continents. In most cases, sibilant harmony involves fricative contrasts like /s/ vs. /ʃ/ (though the precise nature of the phonetic distinction may vary

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[6] In an earlier experimental study, Levitt & Healy (1985) had failed to find this asymmetry. However, as pointed out by Stemberger (1991), this was likely due to the design of the target stimuli used in their experiment. Levitt & Healy used simple CV nonsense syllables, and the priming pairs were exactly identical to the errors being primed. It is thus impossible to determine whether a given error was truly a phonological error (involving single-segment substitution) or a 'lexical error' (with whole-syllable substitution). As Stemberger points out, the latter would not be expected to show any sort of Palatal Bias effect; the sensitivity of the experiment was thus severely decreased, and this may account for the null results obtained.

from language to language, and is not always clearly indicated in descriptive sources), and often the corresponding affricates, like /ts/ vs. /tʃ/, are involved as well. The claim advocated here, that the sources of consonant harmony are to be found in the domain of speech planning, makes the prediction that any generalizations that are found to characterize segmental speech errors are expected to manifest themselves (at least to some degree) in the typology of consonant harmony systems. This has already been argued to be the case for directionality effects—the predominance of anticipatory (regressive, right-to-left) interaction in speech errors and consonant harmony processes alike—as well as the central facilitating role of relative trigger-target similarity in both types of phenomena. Given that contrasts like /s/ vs. /ʃ/ are so frequently involved in consonant harmony, we ought to expect to find some analogue of the Palatal Bias in (some) coronal harmony systems. As will be argued in the remainder of this chapter, the Palatal Bias does indeed manifest itself in the cross-linguistic typology of coronal harmony. This is true not only of sibilant harmony systems of the s-ʃ type, but also of the much rarer harmony type in which alveolar stops and 'palatal' affricates interact (i.e. t-tʃ). These are precisely the segment pairs for which Palatal Bias effect were originally documented, as illustrated in (6) and (7) above.

Note that in the above discussion of Palatal Bias effects in speech errors, no attempt was made to explain *why* such asymmetries exist in the first place. One reason is that the Palatal Bias has as yet not received a fully satisfactory explanation. However, the question of what underlies the Palatal Bias as such is largely orthogonal to the issue at hand. The main point here is to demonstrate that the Palatal Bias—a phenomenon that is characteristic of speech errors, arising in the process of phonological encoding for speech production—is replicated in the typology of coronal harmony systems. This serves as additional evidence that consonant harmony in general, and coronal harmony in particular, has its roots in the speech planning domain.

Nonetheless, it is worth noting that one attempt has been made at explaining the Palatal Bias, by Stemberger (1991). The gist of Stemberger's proposal is to reduce the Palatal Bias to another independently established asymmetry which is also found to obtain in speech error data. This is the so-called Addition Bias (Stemberger & Treiman 1986): the tendency to add consonants to singleton consonants (resulting in a consonant cluster) is considerably greater than the tendency to remove consonants from clusters (resulting in a singleton consonant). For example, in sequences like *back blocks* or *black box*, a speaker is more likely to produce an error like *black blocks* than *back box*. This Addition Bias has been documented in corpora of naturally occurring errors in the speech of adults (Stemberger & Treiman 1986) as well as children (Stemberger 1989). It has also been replicated in several experimental studies of artificially induced errors (Stemberger & Treiman 1986, Stemberger 1991). The existence of an Addition Bias—whatever its explanation might be—has thus been securely demonstrated.

What Stemberger (1991) argues is that the Palatal Bias can be reduced to a special case of the Addition Bias, given certain assumptions about phonological underspecification. The idea is that 'palatals' like /tʃ/ or /ʃ/ are fully specified as being [–anterior], whereas the alveolars like /t/ or /s/ are lexically unspecified for their (unmarked) [+anterior] feature value, in accordance with the theory of Radical Underspecification (Kiparsky 1982, 1985, Archangeli 1984, Paradis & Prunet 1991). Based on this assumption, an error in which /s/ is replaced by /ʃ/ constitutes the *addition* of a feature specification, whereas the reverse replacement of /ʃ/ with /s/ involves *removal* of that same [–anterior] element. From this perspective, such changes are then roughly parallel to singleton/cluster interactions like /b/ → /bl/ and /bl/ → /b/, respectively. Both can be attributed to the same basic effect, namely the Addition Bias. Stemberger (1991) goes on to show that other feature-specification asymmetries implied by radical underspecification are also matched by asymmetries in experimental speech error data. For example, he finds the change alveolar → labial to be more common than labial → alveolar (59 vs. 32), whereas labial vs. velar interactions do not show this kind of asymmetry. This is consistent with the hypothesis that alveolars are unspecified for Place, whereas labials and velars are not. Stemberger also finds that for obstruents differing only in voicing, the change voiceless → voiced is more common than voiced → voiceless; this is as expected if voiceless obstruents are unspecified for [±voice] (or if [voice] is a privative feature). Finally, in errors involving homorganic nasals vs. stops (voiced or voiceless), the change stop → nasal was more frequent than nasal → stop, consistent with the hypothesis that stops are unspecified for nasality. Errors involving fricatives and nasals did not show any such asymmetry; Stemberger's proposed explanation for this is that [±continuant] is specified in fricatives but not nasals, whereas [±nasal] is specified in nasals but not fricatives.

The findings reported by Stemberger (1991) are quite interesting, though in some cases the effects (i.e. the asymmetries) are relatively weak and the study would be well worth replicating. The implications of these findings for theories of phonological specification have yet to be fully explored. For example, it is unclear to what extent they can be accommodated within other representational alternatives to (radical) underspecification. Finally, it remains to be seen to what extent the other target/intrusion asymmetries reported by Stemberger are mirrored in the typology of consonant harmony. It is suggestive that nasal consonant harmony predominantly involves nasalization (e.g., /d/ → [n] or /k/ → [ŋ]) rather than denasalization, and that obstruent voicing harmony typically involves assimilation to [+voice] rather than to [–voice] (see §2.4.4 and §2.4.7). Both fit the asymmetric patterns emerging from Stemberger's experimental findings.

6.3. Palatal Bias Effects in Sibilant Harmony Systems

The single most common type of consonant harmony in the world's languages is sibilant harmony: long-distance assimilatory interactions among strident fricatives and/or affricates. Within the class of sibilant harmony systems, the phonological parameter involved is most commonly an alveolar vs. 'palato-alveolar' (i.e. postalveolar) distinction, such that the interacting consonants are /s/, /ts/, etc., as against /ʃ/, /tʃ/, and so forth. On the assumption that consonant harmony is homologous to phonological speech errors, these are precisely the sorts of interactions that would be expected to be shaped by the Palatal Bias in one way or another. The fact that consonant harmony of this type is relatively well attested cross-linguistically makes it all the more reasonable to expect to find some manifestation of the Palatal Bias in sibilant harmony systems. In this section we will see that this is indeed the case: assimilatory changes like /s/ → [ʃ] (triggered by a nearby [ʃ]) are far more common than, and in some cases take precedence over, their mirror images like /ʃ/ → [s]. The argument crucially depends on the distinction between *featurally symmetric* and *featurally asymmetric* harmony systems, and this dichotomy will therefore be clarified first.

6.3.1. Featural Symmetry in Consonant Harmony Systems

Simply defined, a harmony system based on the feature [±F] is *symmetric* if both feature values are equally active. In other words, in a symmetric system the property being transmitted from trigger to target can be either [+F] or [–F]. For example, in a symmetric *directional* harmony system (with fixed anticipatory directionality), the effect of the harmony is simultaneously [–F]…[+F] → [+F]…[+F] and [+F]…[–F] → [–F]…[–F]. In the first case harmony results in the change (unfaithful mapping) [–F] → [+F], whereas the latter case involves the reverse change [+F] → [–F]. In a symmetric *stem-controlled* system, the same is true, but here the assimilation is to whatever feature value is in the base of affixation. If the stem contains [+F], then we find [–F] → [+F] in affixes attaching to that stem; if the stem has [–F], affixes will show the change [+F] → [–F].[7]

A harmony system is featurally *asymmetric* if only one value of [±F] is 'active' or 'dominant' (elsewhere in this study, this has also been referred to as a 'single-value' harmony system). In an asymmetric system in which only [+F] triggers assimilation, harmony will only produce changes of the type [–F] → [+F], never [+F] → [–F]. A dominant-recessive harmony system, where one feature value spreads bidirectionally (regardless of morphological constituent structure), is by definition asymmetric. For example, in a dominant-recessive [ATR] harmony where the dominant/active value is [+ATR], recessive [–ATR] vowels always assimilate to dominant [+ATR] vowels, in [–ATR]…[+ATR] and [+ATR]…[–ATR] sequences alike; hence the only change observed is [–ATR] → [+ATR].

As noted in §3.1 above, truly dominant-recessive consonant harmony systems do not appear to be attested in the world's languages. Instead, those asymmetric consonant harmony

[7] The clearest instance of a featurally symmetric harmony system is where (potential) target segments underlyingly contrast for [±F], and harmony has the effect of obliterating this contrast. For example, in a symmetric stem-controlled system, affix segments of the relevant kind are neutralized to [+F] or [–F] depending on whether the stem contains a [+F] or [–F] trigger, respectively, whereas the underlying specification of an affix segment as [+F] or [–F] emerges with stems containing no harmony trigger (e.g., no consonant of the relevant type). In other words, a harmony system of this kind is truly *feature-changing*. While this state of affairs is not uncommon in consonant harmony systems (e.g. in Athapaskan and Chumashan languages), it is virtually unattested for vowel harmony. See Hansson (2008b) for an explanation of this typological asymmetry in terms of learnability factors and diachronic change.

systems that are attested are either of the stem-controlled or directional variety. An example of an asymmetric directional system is Ngizim obstruent voicing harmony (see §2.4.7 and §4.2.3). In this system, the only change observed is [–voice] → [+voice]: a disharmonic obstruent sequence of the [–voi]…[+voi] kind is harmonized to [+voi]…[+voi], whereas the equally disharmonic [+voi]…[–voi] remains intact and is not subject to assimilation (neither to [–voi]…[–voi] nor [+voi]…[+voi]). An example of an asymmetric stem-controlled system is the nasal consonant harmony found in many Bantu languages (see §2.4.4 for examples, and §4.3.3 for discussion of how these systems go beyond mere stem control). Here harmony typically results only in [–nasal] → [+nasal], not [+nasal] → [–nasal].[8] In affixes, an underlyingly oral /d/ or /l/ is changed to [n] when the preceding stem contains a nasal, but a nasal /n/ is not denasalized (e.g. in reciprocal /-an-/) in harmony with a (voiced) oral consonant in the preceding stem.

In cases like the aforementioned ones, the harmony system as a whole is asymmetric, in that one feature value is consistently active ([+voice], [+nasal]) whereas the opposite value is consistently inactive ([–voice], [–nasal]). Another possibility is that both feature values do participate in the harmony—that is, each feature value does trigger assimilation—but that harmony in [αF] is somehow restricted or curtailed in comparison to [–αF] harmony. For example, the assimilatory change [+F] → [–F] may be subject to more stringent conditions on the relative similarity (or proximity) of the trigger-target consonant pair than the reverse change [–F] → [+F] is. In systems with these characteristics, the asymmetry is confined to particular contexts; they might therefore be referred to as partially symmetric rather than fully asymmetric.

In the form in which it has been documented in speech error studies, the Palatal Bias is essentially a featural asymmetry, whereby alveolars like [s] or [t] are replaced by 'palatals' like [ʃ] or [tʃ] more frequently than the other way around. A substitution like [s] → [ʃ] is thus more common than its mirror image [ʃ] → [s]. If there is any analogue to the Palatal Bias to be found in the domain of phonological sibilant harmony processes, this would be most likely to manifest itself in the class of featurally asymmetric (or partially symmetric) sibilant harmony systems. The prediction is that in systems that display any sort of asymmetry, the bias should be in favor of 'palatalizing' assimilations (/s/ → [ʃ], or at least a favoring of [ʃ] over otherwise expected [s]) at the expense of 'depalatalizing' assimilation (/ʃ/ → [s]). The data reported in the following section, extracted from the survey of chapter 2, show that this is indeed the case. With virtually no exceptions, all attested asymmetries in sibilant harmony systems are consistent with the Palatal Bias.

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[8] An interesting exception to this is Tiene (Ellington 1977, Hyman & Inkelas 1997, Hyman 2006); see §2.4.4 and §4.3.3 for details.

6.3.2. Asymmetric Sibilant Harmony and the Palatal Bias

In the database of consonant harmony systems on which the present study is based, sibilant harmony systems—especially of the s/ʃ variety—are quite common. However, not all of these can be categorized as featurally symmetric or asymmetric. For example, when sibilant harmony operates as a morpheme-internal restriction, there is often no direct evidence of the assimilatory processes responsible for giving rise to the static co-occurrence pattern observed. It is in principle possible to interpret a system that allows only [s…s] and [ʃ…ʃ] morpheme-internally as an asymmetric system of the 'dominant-recessive' type with only /s/ → [ʃ] (i.e. where hypothetical /s…ʃ/ and /ʃ…s/ inputs would both get harmonized to [ʃ…ʃ]). But it is equally possible to view it as a featurally symmetric system, for example with consistent anticipatory directionality (where /s…ʃ/ → [ʃ…ʃ] and /ʃ…s/ → [s…s]). Typically, when a sibilant harmony system is confined to morpheme-internal contexts in this way, the only evidence that can be brought to bear on the symmetry question is *diachronic*, for example based on comparative reconstruction. A closely related dialect or language (or a documented earlier stage of the same language) may reveal precisely how the harmony asserted itself in words which originally contained a /ʃ…s/ or /s…ʃ/ sequence. But such evidence is rarely available, rendering it impossible to determine whether the harmony is/was symmetric or asymmetric.

Leaving aside such indeterminate cases, the consonant harmony database contains a considerable number of symmetric sibilant harmony systems that are based on contrasts of the s-ʃ type. These are listed in (8); regarding the questionable status of Misantla Totonac as a symmetric system, see §6.3.3 below. [9]

[9] With respect to Plains Apache (Kiowa Apache), Bittle (1963) describes its sibilant harmony as involving *partial* assimilation, with the resulting sibilants being intermediate in phonetic quality between those of the /s/ and /ʃ/ series. (Furthermore, he seems to imply that in terms of their quality, 'harmonized' /s/-series sibilants and 'harmonized' /ʃ/-series sibilants are even distinct from *each other*—which would be rather remarkable.) If Bittle's characterization is correct, this is a very interesting fact, but one which does not bear on the classification of Plains Apache sibilant harmony as a symmetric system rather than an asymmetric one.

(8) Symmetric sibilant harmony systems (/s/ → [ʃ] and /ʃ/ → [s] alike):

Navajo (Athapaskan)
Chiricahua Apache (Athapaskan)
Plains Apache (Athapaskan)
Tanana (Athapaskan)
Barbareño (Chumashan)
Ineseño (Chumashan)
Ventureño (Chumashan)
Southern Paiute (Uto-Aztecan)
Nebaj Ixil (Mayan)
?Misantla Totonac (Totonacan)

Most of the languages listed in (8) belong to the Athapaskan and Chumashan language families. In all of the symmetric systems found in either of these two families, the featurally symmetric character of the harmony can be directly observed in that it results in surface alternations which obliterate underlying (lexical) contrasts like /s/ : /ʃ/ or /ts/ : /tʃ/ in roots and/or in affixes. This can be seen from examples such as the ones in (9) from Ineseño, a symmetric system with fixed (anticipatory) directionality. In (9a), the 3Obj suffix /-us/ triggers [+anterior] harmony in the preceding stem morpheme /-tʃʰo-/, resulting in the change /tʃʰ/ → [tsʰ]. When the past tense suffix /-waʃ/ is added, as in (9b), its sibilant triggers [–anterior] harmony, causing the stem affricate to revert to [tʃʰ], as well as causing the change /s/ → [ʃ] in the /-us/ suffix that precedes it. The changes involved in Ineseño sibilant harmony are thus both [–ant] → [+ant] (9a) and [+ant] → [–ant] (9b).

(9) Symmetric sibilant harmony in Ineseño (data from Applegate 1972):

a.	/s-api-tʃʰo-us/	[sapitsʰolus]	‘he has a stroke of good luck’
b.	/s-api-tʃʰo-us-waʃ/	[ʃapitʃʰoluʃwaʃ]	‘he had a stroke of good luck’

Similar effects can be directly observed in other Chumashan languages, as well as in the Athapaskan languages listed in (8), such as Navajo. In another case mentioned in (8), the Nebaj dialect of Ixil (Mayan), the evidence for the symmetric character of the harmony is mostly diachronic-comparative. Based on a comparison with cognate forms in the neighboring Chajul dialect, it can be concluded that Nebaj Ixil sibilant harmony is a symmetric system with fixed anticipatory directionality. A further indication is the fact that sibilant harmony is to some extent optional, resulting in the Nebaj dialect having a number of doublet forms, one disharmonic and the other harmonized. This is illustrated in (10). Note that Nebaj Ixil sibilant harmony is in fact a three-way system, involving the alveolar, ‘palatal’ (lamino-postalveolar) and retroflex sibilant series.

(10) Evidence for symmetric sibilant harmony in Ixil (data from Ayres 1991)

a. Comparative evidence (Nebaj vs. Chajul dialects)

Nebaj	*Chajul*	
tʃitʃam	ʈʂitʃam	'coach, car'
tʃ'atʃ	ʈʂ'atʃ	'bed'

b. Doublet forms in the Nebaj dialect

tʃ'is ~ ts'is	'garbage'
tʃ'isis ~ ts'isis	'cypress'
tʃ'eveʂ ~ ʈʂ'eveʂ	'annona, custard apple'
tʃ'iʂi ~ ʈʂ'iʂi	'white oak'
siːn-ʂeʔ ~ ʂiːn-ʂeʔ	'with me'

A considerably more common state of affairs is for sibilant harmony systems to be asymmetric (or partially symmetric) in the sense defined in the previous section. In an asymmetric system, the harmony will only manifests itself in the change [+ant] → [–ant], or else only in [–ant] → [+ant]. If the Palatal Bias manifests itself in sibilant harmony, we should predominantly expect to see systems in which the former type of change is privileged in some way. This is indeed borne out. The table in (11) lists all asymmetric sibilant harmony systems of the relevant kind that are attested in the consonant harmony database. Note that in the headings in (11), 's' and 'ʃ' stand for entire series of alveolar and 'palatal' sibilants, respectively; often voiced fricatives like [z, ʒ] and/or affricates like [ts, tʃ] participate in the harmony as well. Where different dialects or closely related languages are involved, but the available descriptive sources are insufficient to rule out the possibility of differences across dialects, these are lumped together (e.g. Berber, Coptic). Two of the languages listed here as asymmetric, Nkore-Kiga and Tzeltal, are strictly speaking partially symmetric, as will be discussed below.

(11) Asymmetric sibilant harmony systems

/s/ → [ʃ] only:	/ʃ/ → [s] only:
Tsuut'ina (Sarcee; Athapaskan)	Tlachichilco Tepehua (Totonacan)
Dene-tha (Slave; Athapaskan)	
Wiyot (Algic)	
Tzeltal (Mayan)	
Aari (Omotic)	
Koyra (Omotic)	
Benchnon (Gimira; Omotic)	
Zayse (Omotic)	
Moroccan Arabic (Semitic)	
Berber (various dialects; Afro-Asiatic)	
Coptic (various dialects; Afro-Asiatic)	
Nkore-Kiga (Bantu)	

Rwanda (Bantu)
Rundi (Bantu)
Shambaa (Bantu)
Izere (Bantu)

The overview in (11) speaks for itself: in all but one case, the asymmetry is in the direction predicted by the Palatal Bias. The sole counterexample to this generalization, Tlachichilco Tepehua, will be dealt with in §6.3.3 below.

As an illustration of an asymmetric sibilant harmony system consider the data in (12) from the Athapaskan language Tsuut'ina (Sarcee; Cook 1979, 1984). This language exhibits anticipatory sibilant harmony, whereby a /s/-series ([+anterior]) sibilant will change into its /ʃ/-series ([–anterior]) counterpart when followed by a /ʃ/-series sibilant later in the word. In these examples, the stem is shown in boldface.

(12) Asymmetric sibilant harmony in Tsuut'ina (data from Cook 1979, 1984)

a.	/sí-**tʃíz**-àʔ/	[ʃítʃídzàʔ]	'my duck'
	/sì-**tʃógò**/	[ʃìtʃógò]	'my flank'
b.	/nā-s-**ɣátʃ**/	[nāʃɣátʃ]	'I killed them again'
c.	/sá#ts'ì-gù-sì-ni-s-**jáj**/	[ʃátʃ'ìgùʃìʃáj]	'you forgot me'

In the (12a) examples, the 1SgPoss prefix /si-/ undergoes harmony to [ʃi-] under the influence of a [tʃ] in the following noun stem. In (12b), the same goes for the verbal 1SgSubj prefix /s-/. Finally, in (12c), the incorporated postpositional phrase /sá-/, the deictic subject marker /ts'i-/ and the perfective marker /si-/ all undergo harmony, triggered by the [ʃ] that results from fusion of the valence prefix /s-/ with a root-initial /j/. In all cases, the change involved is [+anterior] → [–anterior].

Though descriptive sources on Tsuut'ina clearly state that the sibilant harmony involves 'palatalization' to the exclusion of 'depalatalization', hard evidence for this asymmetry—forms showing that harmony *fails* to apply in underlying sequences like /ʃ…s/ or /ʃ…ts/—is not easy to come by. This is because /ʃ/-series sibilants are virtually absent from prefixes in Tsuut'ina. Nevertheless, forms such as the first example in (12a) do constitute evidence for the asymmetry: if Tsuut'ina sibilant harmony were symmetric, we would expect /sí-**tʃíz**-àʔ/ to turn out as *[sítsídzàʔ], with the rightmost [(d)z] triggering [+anterior] harmony, instead of the observed [ʃítʃídzàʔ]. In fact, we would expect a morpheme like /-tʃí(d)z-/ with its underlying [–ant]…[+ant] sibilant sequence, to be impossible in the first place.

As noted above, two of the asymmetric examples in (11) are, strictly speaking, partially symmetric rather than completely asymmetric: Nkore-Kiga (Bantu) and Tzeltal (Mayan). In these languages, both 'palatalizing' (/s/ → [ʃ]) and 'depalatalizing' (/ʃ/ → [s]) effects are found, but the latter are restricted in ways that the former are not. In other words, certain contexts exist where the sibilant harmony is asymmetric, even though it is fully symmetric in other contexts. This aspect of Nkore-Kiga sibilant harmony was discussed in detail in §5.3.3 above, and the particulars do not need to be repeated here. The general facts are as follows: When the trigger and target are in (the onsets of) adjacent syllables, *and* agree in voicing ([s] vs. [ʃ], or [z] vs. [ʒ]), the harmony is fully symmetric: we find harmonic [ʃ…ʃ], [ʒ…ʒ] in place of disharmonic *[s…ʃ], [z…ʒ], and we also find harmonic [s…s], [z…z] replacing disharmonic *[ʃ…s], [ʒ…z]. However, when the two sibilants disagree in voicing, or are in non-adjacent syllables, the harmony is *asymmetric*, with regressive assimilation in [–anterior] but not in [+anterior]. For example, disharmonic sequences of the type *[s…C…ʃ] are still avoided (in favor of [ʃ…C…ʃ]), whereas disharmonic [ʃ…C…s] sequences do occur and are not repaired by sibilant harmony. Again, the asymmetry is in the direction consistent with the Palatal Bias.

As for the other partially symmetric case, the Mayan language Tzeltal, the facts are less clear, owing to the nature of descriptive sources consulted for this study. In Kaufman's (1971) analysis of Tzeltal morphophonemics, it appears that /s/ → [ʃ] when followed by a /ʃ/-series sibilant ([ʃ, tʃ, tʃ']), as in /s-wàkaʃ/ → [ʃwákaʃ] 'his cattle'.[10] On the other hand, the reverse change /ʃ/ → [s] (and similarly /tʃ/ → [ts] and /tʃ'/ → [ts']) appears to take place only when the sibilant in question is simultaneously followed and preceded by [s], as in the form /s-kùʃ-ʰ-es-ik/ → [skúsesik] 'they revive'. The 'depalatalizing' version of Tzeltal sibilant harmony thus appears to be more constrained than its 'palatalizing' counterpart, exactly in accordance with the Palatal Bias.[11]

To sum up, the Palatal Bias evident in speech error studies is robustly replicated in the cross-linguistic typology of sibilant harmony systems that revolve around an alveolar vs. 'palatal' distinction. As a surface manifestation of harmony, the assimilatory change /s/ → [ʃ] is far more common than the reverse change /ʃ/ → [s]. With virtually no exceptions (though see §6.3.3 below) any asymmetry is in the expected direction. Interestingly, the handful of examples of sporadic sound changes cited as instances of 'consonant-harmonization' by Jespersen (1904, 1922; see §1.2.1 above) show the exact same asymmetry. One of these is the French sound change *cercher* > *chercher* (cf. English *search*, borrowed before the change), where the historical development is [s…ʃ] > [ʃ…ʃ]. Another is the 'vulgar' pronunciation [ʃerˈʃant] ~ [ʃerˈʒant] 'sergeant' in Danish and German, instead of correct [serˈʃant] or [serˈʒant]. Here too we find [s…ʃ] > [ʃ…ʃ] or [s…ʒ] > [ʃ…ʒ], with anticipatory [–anterior] assimilation. Even though these historical examples constitute sporadic rather than systematic changes, both are fully parallel to the regular synchronic-phonological processes found in languages like Tsuut'ina, as described above.

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[10] Because of the paucity of data cited in Kaufman (1971), it is hard to tell whether the /s/-series affricates /ts, ts'/ are actually *excluded* from this harmony, or whether the relevant sibilant sequences (e.g. /ts…ʃ/) simply never arise in morpheme concatenation.

[11] To complicate matters even further, /ʃ/ also becomes [s] by harmonizing to [s, ts, ts'] 'in the following syllable with no intervening written juncture except ‖^‖' (Kaufman 1971:22).

6.3.3. Apparent Counterexamples

In the listing of asymmetric sibilant harmony systems in (11), the sole example of a language where the asymmetry favors [+anterior] over [–anterior] is Tlachichilco Tepehua, a Totonacan language (Watters 1988). Some examples of sibilant harmony in Tlachichilco Tepehua are shown in (14). Harmony is directional (regressive), with /ʃ/-series sibilants assimilating to a /s/-series sibilant occurring later in the word, as in (14a). By contrast, /s/-series sibilants do not appear to undergo harmony when followed by a /ʃ/-series sibilant, as (14b) shows.

(14) 'Alveolar Bias' in Tlachichilco Tepehua sibilant harmony (Watters 1988)

a. Anticipatory [+anterior] harmony:

/tʃ'an-q'isiːti/ (foot-nail)	[ts'anʔesiːti]	'toe nail'	
/ʔukʃ-k'atsaː/ (surface-know)	[ʔuksk'atsaː]	'feel, experience sensation'	
/ʔaqʃ-kis/ (CLAS-five)	[ʔaqskis]	'five flat things'	

b. No anticipatory [–anterior] harmony:

/tasa-ʃka-/ (tooth-hurt)	[tasaʃka-]	'tooth ache'	(not *[taʃaʃka-])
/pas-tʃaʃan/ (CLAS-six)	[pastʃaʃan]	'six bundles'	(not *[paʃtʃaʃan])

Watters (1988:503) explicitly describes sibilant harmony as asymmetric in this way: 'there are no cases of sibilant harmony that involve an [s] or [ts] becoming [š] or [tš] preceding an alveopalatal'. It should be noted that sibilant harmony is optional in Tlachichilco Tepehua; all speakers consulted by Watters accepted unassimilated pronunciations as well-formed, even in cases like (14a), though assimilation is the more common state of affairs.

Misantla Totonac, another language of the Totonacan family, also has a sibilant harmony system similar (and possibly cognate) to that of Tlachichilco Tepehua (MacKay 1999). This harmony is likewise optional, but differs from its Tepehua counterpart in that it is confined to the stem domain, which consists of the root plus any derivational (but not inflectional) prefixes. Unlike in Tlachichilco Tepehua, sibilant harmony in Misantla Totonac was counted among the featurally *symmetric* systems in (8) above. This is based on the description in MacKay (1999), who explicitly describes sibilant harmony as a symmetric process. She first discusses sibilant assimilation under adjacency, that is, in consonant clusters (/s+tʃ/ → [ʃtʃ], /ʃ+ts/ → [sts], etc.); this she formalizes as an autosegmental process of leftward spreading of [±anterior] between the [Coronal] articulator nodes of [+strident] segments. MacKay then goes on to describe sibilant harmony in the following way:

> Strident assimilation also applies optionally across intervening segments within a stem. […O]nly derivational prefixes are affected. When a stem contains two strident segments, /č/ [= /tʃ/] or /¢/ [= /ts/] and /s/ or /š/ [= /ʃ/], the feature [anterior] spreads from right to left […] (MacKay 1999:57)

Though MacKay unequivocally describes Misantla Totonac sibilant harmony as a symmetric process, transmitting the binary feature [±anterior] as such, rather than just the specific feature value [+anterior], she unfortunately cites only two examples to illustrate this harmony, shown in (15). Both involve the /tʃ/ of the body-part prefix /tʃa̰ː-/ as the harmony target, as shown in (15a); the example in (15b) demonstrates that this affricate is underlyingly specified as [–anterior].

(15) Sibilant harmony in Misantla Totonac (data from MacKay 1999)

a.	/tʃa̰ː-sta̰lah/	[tsa̰ːsta̰lɛh]	'clean-bodied'
	/tʃa̰ː-spit/	[tsa̰ːspɪt]	's/he peels X (trunk-like object)'
b.	/min-tʃa̰ː-nḭ/	[miɲtʃa̰ːn]	'your body'

Because /tʃa̰ː-/ happens to have a /ʃ/-series sibilant, the only illustration MacKay (1999) gives us of Misantla Totonac sibilant harmony involve the exact same type of change—in an 'Alveolar Bias' direction (/tʃ/ → /ts/)—as that found in the related Tlachichilco Tepehua. It is therefore conceivable that Misantla Totonac displays an asymmetry in the 'wrong' direction, just like Tlachichilco Tepehua. However, this would have to entail that MacKay's description in the passage quoted above (as well as her autosegmental analysis) are rather misleading.

The reason for this ambiguity may have something to do with the fact that sibilant harmony is optional in Misantla Totonac (as it is in Tlachichilco Tepehua). Another potentially confounding factor is the coexistence of sibilant harmony with a pervasive system of *sound symbolism*, widespread throughout the Totonacan family. Many Totonacan languages display sound-symbolic alternations related to semantic 'intensity', illustrated in (16); these partly involve the /s/- vs. /ʃ/-series contrast (see MacKay 1999:113 and references cited there).

(16) Misantla Totonac: sound-symbolic sibilant alternations (MacKay 1999)

/s/-series		*/ʃ/-series*	
/tsukṵnkṵ/	'cool'	/tʃukṵnkṵ/	'cold'
/tsṵtsṵ/	's/he smokes'	/tʃṵtʃṵ/	's/he sucks'
/squ-kuhu-la(ɨ)/	'it was all smoked'	/ʃqu-kuhu-la(ɨ)/	'it was blackened'
/muksun/	'little, few'	/mukʃun/	'a few (handful)'

MacKay notes that these sound-symbolic alternations are no longer very productive in Misantla Totonac, and have in many cases lost all correlation with systematic semantic differences.

As a result, there are numerous examples of doublet forms, where a given morpheme may contain either a /s/-series or a /ʃ/-series sibilant, without a corresponding change in meaning:

(17) Misantla Totonac: doublet forms with sibilants (MacKay 1999)

/ʃqu̯q/ ~ /squ̯q/	'salty'
/tʃaʃaʃ/ ~ /tsasas/	'white'
/tʃiʃit/ ~ /tsisit/	'hairs'

There is reason to believe that the simultaneous involvement of the /s/-series vs. /ʃ/-series distinction in this elaborate sound symbolism pattern and in a systematic phonological process of sibilant harmony is not accidental. Recall that Misantla Totonac and Tlachichilco Tepehua also display dorsal consonant harmony (see §2.4.2). It so happens that the very same /k/ vs. /q/ contrast on which that harmony is based *also* enters into the sound-symbolic alternations of Misantla Totonac (e.g. /staq-ni̯/ 'green' vs. /stak-ni̯/ 'flower that just bloomed'). It would seem to be a spectacular coincidence that the phonological distinctions that form the basis of consonant harmony interactions also happen to be precisely the ones participating in sound-symbolic alternations.[12] Furthermore, the domain in which both of the consonant harmonies operate is the derivational stem—a relatively lexicalized morphological constituent—which is somewhat parallel to the domain within which sound symbolism alternations tend to operate.

Note that sound-symbolic alternations such as those in (16) and (17) result in a superficial pattern of global agreement in [±anterior] among the sibilants that co-occur within a word or stem. This is of course true of sibilant harmony as such: it causes all sibilants within a word (or, in Misantla Totonac, the derivational stem) to surface with matching [±anterior] values. This invites the conjectural historical explanation that Totonacan consonant harmony may have arisen by way of analogical reanalysis of the surface patterns caused by sound symbolism. As the sound-symbolic alternations became less and less transparently connected to systematic semantic factors, these pervasive [±anterior] agreement patterns were reinterpreted as being due to a *phonological* (phonotactic) restriction demanding that all sibilants within a domain carry identical values for [±anterior].

More detailed descriptive and comparative-historical sources would need to be consulted in order for this hypothesis to go beyond the realm of pure speculation. Nevertheless, if the sibilant harmony observed in Totonacan languages did indeed arise through analogical reanalysis of distribution patterns originally due to sound symbolism, then this may shed some light on the typologically anomalous character of Tlachichilco Tepehua among the lan-

[12] To be exact, the sound-symbolic alternations among coronal continuants are a three-way system, involving not only /s/ and /ʃ/ but also the lateral fricative /ɬ/. In some other Totonacan languages, there are three-way alternations among affricates as well, /ts/ vs. /tʃ/ vs. /tɬ/, but Misantla Totonac lacks a lateral affricate /tɬ/ (having merged it with /t/).

guages listed in (11). If the emergence of Totonacan sibilant harmony did not involve phonologization of speech errors (or the functional exigencies of speech planning that underlie such errors), then we should not have any particular reason to expect this harmony system to conform to the Palatal Bias in the first place. The explanation for its *synchronically* anomalous properties may lie in its (somewhat) anomalous *diachronic* origins.[13] (Similar arguments are applied to certain problematic cases of obstruent voicing agreement and secondary-articulation agreement, respectively, in Hansson 2004a, 2007c.)

There are other cases where diachronic considerations can shed light on synchronic anomalies in certain coronal harmony systems. In the database surveyed in the present work, at least two languages with three-way coronal harmony alternations show an unexpected 'latency' of the /ʃ/ series. These are the Athapaskan language Tahltan (Hardwick 1984, Nater 1989, Shaw 1991, Halle 1995, Gafos 1999, Clements 2001, Levi 2004) and the Costanoan language Rumsen (Garrett 1999, based on Miller 1999). In Tahltan, the three series participating in the harmony are /ʃ/ vs. /s/ vs. /θ/ (and similarly /tʃ/ vs. /ts/ vs. /tθ/ as well as /ʒ/ vs. /z/ vs. /ð/, etc.), whereas in Rumsen the relevant three-way contrast is /ʃ/ vs. /s/ vs. /s̺/. What is unusual about both cases is that the /ʃ/-series sibilants appear to be weaker harmony triggers than the coronal obstruents of the other two series. For example, /ʃ/-series sibilants may trigger harmony only optionally, or they may trigger partial assimilation. In Tahltan and Rumsen alike, the explanation of this 'latency' of the /ʃ/ series seems to lie in the historical development of the harmony system. The three-way coronal harmony of Tahltan seems to have developed out of what was originally a two-way system, involving what are now the /s/ vs. /θ/ series. A similar extension scenario can be inferred for Rumsen as well (i.e. that it originally involved only the /s/ vs. /s̺/ series), though the facts are less clear. If this interpretation is correct, then the inclusion of /ʃ/-series sibilants in coronal harmony in Tahltan and Rumsen constitutes a later modification of a pre-existing harmony system. The latency of the /ʃ/ series then reflects the fact that these segments have not been integrated completely into the harmony.

Because it provides a near-parallel to the scenario hypothesized for Totonacan sibilant harmony (in that both involve 'analogical change' in the traditional sense), it is useful to examine Tahltan in greater detail. The basic facts of Tahltan coronal harmony (and its analysis

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[13] A similar scenario involving sound symbolism reanalyzed as consonant harmony may account for another typologically peculiar case, Wiyot coronal harmony (Teeter 1959; see §2.4.1.1 n. 9). Here we find sound-symbolic alternations between /s/ and /ʃ/, as well as between /l/ and /r/. The exact same segments also participate in consonant harmony, which interestingly lumps the two pairs together, such that /s, l/ interact with /ʃ, r/. In other words an [ʃ] elsewhere in the word will trigger the change /l/ → [r], and so forth. Note that in Totonacan, too, two separate contrasts are involved in both sound-symbolic and harmony alternations: /s, ts/ vs. /ʃ, tʃ/ on the one hand and /k/ vs. /q/ on the other. Unlike in Wiyot, there is no 'cross-over' between these in the harmony system: dorsal harmony is independent from sibilant harmony, and the two do not interact.

by Shaw 1991) were described in §1.2.2. To summarize, Tahltan coronal harmony involves the fricatives and affricates of the dental series /θ, ð, tθ, tθ’, dð/, the alveolar series /s, z, ts, ts’, dz/ and the postalveolar or ‘palatal’ series /ʃ, ʒ, tʃ, tʃ’, dʒ/. Harmony obeys anticipatory directionality, with the rightmost coronal of the /θ/, /s/ or /ʃ/ series triggering harmony on all earlier coronals belonging to any of these series. This is illustrated by the examples in (18) and (19), taken from Shaw (1991). The data in (18) show harmony affecting an underlying /s/-series consonant, whereas in (19) the target is an underlying /θ/-series consonant. Note that the plain coronal series /t, t’, d, n/, as well as the lateral series /ɬ, l, tɬ, tɬ’, dl/, do not participate in the harmony and are transparent to it.[14]

(18) Tahltan: harmony alternations in 1SgSubj prefix /s-/ (Shaw 1991)

a. ɛ-**s**-k’aː ‘I’m gutting fish’
nɛ-**s**-tɛɬ ‘I’m sleepy’

b. na-**θ**-tθ’ɛt ‘I fell off (horse)’
ɛdɛdɛ-**θ**-duːθ ‘I whipped myself’

c. hudi-**ʃ**-tʃa ‘I love them’
noʔɛdɛː-**ʃ**-ɬɛdʒi ‘I melted it over and over’

(19) Tahltan: harmony alternations in 1DuSubj prefix /-θi(d)-/ (Shaw 1991)

a. dɛ-**θ**i-gɪtɬ ‘we threw it’
θiː-tθædi ‘we ate it’

b. dɛ-**s**i-dzɛl ‘we shouted’
xa-**s**iː-dɛts ‘we plucked it’

c. u-**ʃ**i-dʒɛ ‘we are called’
mɛʔɛ-**ʃ**i-t’otʃ ‘we are breast-feeding’

Phonological analyses of Tahltan coronal harmony have interpreted the nature of the distinction between the /θ/, /s/ and /ʃ/ series in different ways. Gafos (1999) views this as a three-way scalar contrast, based on the articulatory parameter Tongue-Tip Constriction Area (TTCA). The TTCA value is [wide] for the /θ/ series, [narrow] for the /s/ series, and [mid] for the /ʃ/ series. On this interpretation, coronal harmony simply involves the leftward extension of a particular TTCA setting across the word. Shaw (1991), whose analysis makes crucial appeal to radical underspecification, suggests that under the [coronal] articulator node, the /θ/-series consonants are specified as [+distributed], the /s/ series as [+strident], and the /ʃ/ series [–anterior]. As discussed in §1.2.2, Shaw analyzes the harmony as a process of leftward spreading of the [coronal] node as such.

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[14] In (18), (19) and (20), the only morpheme boundaries shown are the ones demarcating the prefix morpheme being illustrated.

Hardwick (1984) cross-classifies the three series by means of the two binary features [±strident] and [±anterior]. The /θ/ series is [–strident, +anterior], the /s/ series [+strident, +anterior], and the /S/ series [+strident, –anterior]. This allows Hardwick to separate coronal harmony into two distinct processes: leftward spreading of [±strident] on the one hand, and of [±anterior] on the other. This is made necessary by a peculiar asymmetry observed in the data reported in Hardwick (1984). It is precisely this asymmetry that makes the Tahltan case somewhat parallel to the Totonacan one discussed above. What Hardwick found was that while agreement in [±strident] is obligatory and exceptionless, agreement in [±anterior] appears to be optional.

First of all, Hardwick notes that a /ʃ/-series consonant does not consistently trigger harmony in a preceding /s/-series consonant. For example, the 1SgPoss prefix /es-/ regularly assimilates to /θ/-series coronals, yielding [eθ-], but before a /ʃ/-series coronal, unassimilated [es-] 'is the dominant form' (Hardwick 1984:102). Gafos (1999:187) points out that unassimilated [es-] is also found before /θ/-series coronals in several forms cited elsewhere in Hardwick's work (especially on pp. 43ff.). He concludes that 'the harmony may in some sense be optional for all alternations and not just for the s → š one'. Optionality alone is therefore not a strong argument for separating [±strident] harmony from [±anterior] harmony—though it does seem that disharmony of the [s…ʃ] kind is much more commonly encountered in Hardwick's data than [s…θ], *pace* Gafos 1999).[15]

More interestingly, a robust pattern in Hardwick's data is that a /ʃ/-series consonant can trigger *partial* harmony in a preceding /θ/, shifting it to a [s] realization instead of all the way to [ʃ], as shown in (20). Before bases that contain a /ʃ/-series sibilant, the 1DuSubj prefix /-θi(d)-/ we saw in (19) is frequently realized as [si-] rather than the expected [ʃi-].[16]

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[15] Paradigm levelling is a likely explanation in the case of 1SgPoss /es-/, but it also appears that part of the explanation is that in *nominal* prefixes, the coronal assimilations are subject to an adjacency requirement. In the data cited by Hardwick (1984), /es-/ is realized as [eθ-] or [eʃ-] only before stems with an *initial* /θ/- or /ʃ/-series consonant, respectively; an interpretation along these lines is in fact hinted at by Hardwick herself (1984:113, n. 3). It is not clear that this local assimilation, which thus applies in coronal obstruent clusters, should be analyzed as harmony. Consequently, it may be that coronal harmony (in a strict sense) is limited to verbal prefixes in Tahltan, at least for the speakers Hardwick worked with.

[16] The conjugation marker /-θɛ-/ shows the same partial-assimilation behavior; this prefix is often realized as [s(ɛ)-] instead of [ʃ(ɛ)-] before bases containing /ʃ/-series consonants: [ɬɛ-**s**-itʃɪtʃ] 'I tied', [**s**-indʒan̥] 'you are old'.

(20) Partial assimilation in 1DuSubj prefix /-θi(d)-/ (Hardwick 1984)

si-dʒɪn	'we sang'
de-**s**i-dʒih	'we are breathing'
ɬe-**s**i-tʃɪtʃ	'we tied it'
ɬene-**s**i-tʃuʒ	'we folded it'
ʔi-**s**i-tʃut	'we grabbed it'
meʔe-**s**i-t'otʃ	'we are breast-feeding'

On Hardwick's interpretation, the partial assimilation observed in (20) indicates that [±strident] harmony is obligatory, whereas [±anterior] harmony is to some extent optional. The facts in (20) are hard to reconcile with the analyses of Tahltan coronal harmony proposed by Shaw (1991) and Gafos (1999). For Shaw, spreading of a [coronal] node should not be dependent on what subordinate features happen to be specified below that node, and the partial assimilation in (20) is simply impossible to describe in terms of [coronal] spreading. In Gafos' analysis, the /ʃ/ series is assumed to represent the intermediate value [mid] on the TTCA scale, located in between the extremes [wide] and [narrow] (for the /θ/ and /s/ series, respectively). In the partial assimilations in (20), a coronal with a [mid] TTCA value causes a preceding coronal to shift its TTCA value from [wide] to [narrow]; this can hardly be made sense of on the basis of articulatory gestures at all.[17]

In sum, the Tahltan /ʃ/-series consonants are 'weak' harmony triggers in that they do not consistently trigger harmony, and that they may trigger only partial harmony (in [±strident], but not [±anterior]). The explanation almost certainly lies in the fact that these sibilants are 'newcomers' to the Tahltan coronal inventory, and thereby also to the coronal harmony system. As the table in (21) shows, the /ʃ/ series (here represented by the affricate /tʃ/) is the historical reflex of what was in Proto-Athapaskan (PA) a *front velar* (likely dorso-palatal) series, reconstructed as **k̑*, **x̑*, etc. (see Cook & Rice 1989; cf. Hansson 2007c).

(21) Proto-Athapaskan and Tahltan correspondences:

PA:	*ts	*tš/*tšʷ	*k̑
	|	|	|
Tahltan:	/tθ/	/ts/	/tʃ/

[17] Shaw (1991) does not report any asymmetries like the ones in (20)—quite possibly dialect or age-group differences between native-speaker consultants are to blame—nor does she address the implications of the facts reported by Hardwick. Gafos (1999:187) does note the asymmetry discussed by Hardwick, namely that the /s/ → [ʃ] alternation alone is optional, admitting that '[t]his would be a rather puzzling difference'. However, he does not comment on the partial-assimilation facts in (20), which would seem far more problematic for his analysis than the optionality issue.

There is good reason to believe that the coronal harmony that appears in Tahltan originally encompassed only the /θ/ and /s/ series, that is, the reflexes of the Proto-Athapaskan *ts and *tš/*tš^{w} series. Firstly, these are exactly the series which were subject to (morpheme-internal) coronal harmony already in Proto-Athapaskan-Eyak (Krauss 1964). Secondly, in those daughter languages with coronal harmony that have not merged (their reflexes of) the PA *ts vs. *tš/*tš^{w} series, it is precisely these two series that participate in the harmony. For example, this is true of Navajo and Apache, where the *ts vs. *tš contrast is preserved intact (/ts/ vs. /tʃ/, etc.), and also in Tsilhqot'in (Chilcotin), where the *ts : *tš distinction has eventually developed into a pharyngealization contrast (/ts^{ʕ}/ vs. /ts/, etc.; see Hansson 2007c for details).[18] Tsilhqot'in shares with Tahltan (and a large number of other Northern Athapaskan languages) the 'coronalization' of the PA front velar series (*k̯ > /tʃ/, etc.)—one part of the chain shift that Leer (1996:197) has dubbed the Great Northern Series Shift. It is significant in this context that in Tsilhqot'in, the /ʃ/ series *does not* participate in the coronal harmony; the same was almost certainly once true of Tahltan as well.

The diachronic-comparative evidence thus suggests that in Tahltan, the /ʃ/ series is a secondary addition to what was originally a two-way coronal harmony system (as it is in most other Athapaskan languages that show any harmony at all). It seems plausible that this is the reason why /ʃ/-series coronals do not trigger harmony as consistently as the /θ/- and /s/-series ones do (at least in the phonology of certain speakers).[19] The 'latency' of the /ʃ/ series thus has nothing to do with any inherent phonetic-phonological properties of these segments; the explanation lies in the parochial aspects of the historical development of the harmony system in question. This is exactly what was suggested for Totonacan sibilant harmony earlier in this section. The Tlachichilco Tepehua system displays an asymmetry which is otherwise unattested in the typology of sibilant harmony, but this may be related to the (hypothesized) historical origins of that harmony system in the reanalysis of distributional patterns and alternations that were ultimately due to sound symbolism.

6.4. Palatal Bias Effects in Non-Sibilant Coronal Harmony

We saw in §6.3 how the Palatal Bias is robustly replicated in the cross-linguistic typology of sibilant harmony, the type of consonant harmony that is the most widely attested in the world's languages. However, not all harmony processes involving alveolar vs. 'palatal' (lamino-postalveolar) contrasts fall under the sibilant harmony rubric. In some coronal harmony systems, the interacting segments are alveolar stops on the one hand and 'palatal' af-

[18] As argued in Hansson (2007c), the curious Tsilhqot'in development almost certainly passed through an intermediate stage where the contrast was dental vs. alveolar (/t̪s̪/ vs. /ts/, or possibly /tθ/ vs. /ts/), as it still is in some nearby Northern Athapaskan languages, such as Dakelh (Carrier), Dane-zaa (Beaver) and Kaska—in addition, of course, to Tahltan itself.

[19] Note that the partial-assimilation facts in (20) do not follow from this account.

fricates on the other. The handful of known cases of this type were discussed and illustrated in §2.4.1.2 above. For ease of reference, many of the relevant facts are repeated here.

All coronal stop-affricate harmonies of this type show an asymmetry consistent with the Palatal Bias. As discussed in §6.2 above, phonological speech errors involving a 'palatal' affricate intruding on an alveolar stop (e.g. [tʃ]*im's check* for *Tim's check*) are far more common than the reverse (e.g. [t]*uck's tooth* for *Chuck's tooth*). This is mirrored by the phonological coronal stop-affricate harmonies under consideration here; these all involve the assimilatory change stop → affricate (/t/ → [tʃ] or /d/ → [dʒ]). In other words, the alveolar stop is always the assimilation target, whereas the affricate is the trigger.

One example of this rare phenomenon is the Chadic language Kera (Ebert 1979). In this language, root-internal /t…tʃ/ sequences harmonize to [tʃ…tʃ] (22a); the process appears to be optional to some extent. By contrast, the reverse sequence /tʃ…t/ remains intact (22b).

(22) Root-internal coronal harmony in Kera (data from Ebert 1979)

a. 'Palatalizing' harmony (optional?):

tutʃí ~ tʃutʃí	'tamarind'	
tʃətʃerkə́	'backbone'	(cf. Tupuri /tìtʃèrè/)

b. No 'depalatalizing' harmony:

tʃérté	'split'	(↛ *térté)

In addition to shaping root-internal co-occurrence patterns, the harmony appears to produce some alternations. The feminine gender prefix /t-/ occurs on a variety of nominals, as shown in (23a). When the root it attaches to contains /tʃ/, this triggers harmony in the prefix, at least judging from examples like (23b).

(23) Kera: harmony alternations in feminine prefix /t-/ (data from Ebert 1979)

a.	t-óːjá	'dog (fem.)'	(cf. masc. /k-óːjá/)
	t-eːŋa	'dry (fem.)'	(cf. masc. /k-eːŋe/)
b.	tʃ-əːtʃə́	'small (fem.)'	(cf. masc. /k-oːtʃé/)

A second example is the Dravidian language Pengo (Burrow & Bhattacharya 1970), where the effects of coronal harmony appear to be confined to the root. As shown in (24a), coronal stop-affricate sequences like /t…tʃ/, /t…dʒ/ or /d…dʒ/ undergo harmony, to some extent optionally, by which the preceding /t, d/ assimilates to the following affricate, rather than vice versa.[20] As in Kera, the reverse sequences (/tʃ…t/, etc.) do not harmonize (24b).

[20] Burrow & Bhattacharya (1970) describe /t, d/ as being *dental*, not alveolar. The precise phonetic character of these segments is of no direct relevance to the argument being pursued here, namely the existence of a Palatal Bias in coronal harmony systems of this type.

(24) Root-internal coronal harmony in Pengo (Burrow & Bhattacharya 1970)

a. 'Palatalizing' harmony (optional?):

titʃ- ~ tʃitʃ-	'to eat (past stem)'	(derived from /tin-/ 'eat')
toːtʃ- ~ tʃoːtʃ-	'to show'	
taːndʒ- ~ tʃaːndʒ-	'to weave (a garland)'	
dʒoːtʃ-	'to carry on the head'	(cf. Gondi /toːtʃaːnaː/)
tʃoːndʒ-	'to appear'	(cf. Kuvi /toːndʒ-/)

b. No 'depalatalizing' harmony:

tʃeta man-	'to be awake'	(↛ *teta man-)
tʃinta ki-	'to think; to worry'	(↛ *tinta ki-)
dʒunda	'spinning top'	(↛ *dunda)

Note that although the Pengo harmony is confined to the root, it does nevertheless occasionally produce alternations, as shown by the first example in (24a). The verb 'eat' has the root /tin-/. When the root-final consonant is supplanted by [tʃ] (by an independent morphophonemic process), this feeds harmony, by threatening to produce a surface [t…tʃ] sequence. The root-initial coronal of /tin-/ 'eat' thus alternates between [t] and [tʃ] depending on the tense of the verb (though this kind of alternation can only be observed in a very small number of cases, which might well be synchronically frozen, and thus effectively suppletive).

Yet another case where coronal harmony of this type is manifested as a root-internal co-occurrence restriction—though in this case without producing any alternations—is the variety of Aymara labelled 'Bolivian Aymara' by MacEachern (1999), as represented in the dictionary of de Lucca (1987). Bolivian Aymara places severe restrictions on the morpheme-internal co-occurrence of alveolar stops (/t, t^h, t'/) with 'palatal' affricates (/tʃ, $tʃ^h$, tʃ'/) within morphemes; these are sensitive to laryngeal specifications to some degree. When two co-occurring coronal plosives are both laryngeally specified (i.e. ejective or aspirated), they must either both be alveolar or both must be palatal. Thus sequences like /t^h…$tʃ^h$/, /$tʃ^h$…t^h/, /t'…$tʃ^h$/ or /tʃ'…t^h/ are all excluded from the Bolivian Aymara lexicon, a fact noted by MacEachern (1999). However, my own manual search of word-initial coronal-vowel-coronal sequences in de Lucca (1987) revealed that when one of the coronal plosives is laryngeally unspecified, or when both of them are, the co-occurrence restriction is *asymmetric*. Whereas alveolar…palatal sequences are excluded, palatal…alveolar sequences are allowed and are quite well attested. This is shown in (25).

(25) Coronal harmony in Bolivian Aymara roots (data from de Lucca 1987)

a. /T…Č/ sequences are prohibited:

*t…tʃ
*tʰ…tʃ
*t'…tʃ

b. /Č…T/ sequences are allowed:

tʃatu	'jug, small vessel of clay'
tʃitu	'minute, tiny (dial.)'
tʃʰita	'string, row of objects put on a thread'
tʃ'uta	'collision of two round objects'

Note that the disallowed sequences in (25a) are precisely the ones that are eliminated by (anticipatory) assimilation in languages like Kera and Pengo. It seems reasonable to interpret the static co-occurrence pattern of Bolivian Aymara as being due to the same kind of harmony. In other words, hypothetical sequences like /t…tʃ/ are ruled out because they would get harmonized to [tʃ…tʃ], whereas mirror-image sequences like /tʃ…t/ are not harmonized to [t…t] in the same way. The distributional patterns of Bolivian Aymara thus display a Palatal Bias effect: coronal harmony effects changes of the type /t/ → [tʃ], but not the reverse /tʃ/ → [t].[21]

Finally, it is worth noting that the morphological palatalization processes of Harari (Semitic; Leslau 1958, Rose 1997, 2004) follow the same pattern, though it is unclear to what extent these effects involve consonant harmony in the usual sense. As described in §2.4.1.2 above, a suffix /-i/ triggers 'palatalization' of an immediately preceding stem-final (sometimes stem-medial or even stem-initial) coronal, resulting in such changes as /s/ → [ʃ], /d/ → [dʒ] and /t/ → [tʃ], among others. When the stem contains more than one coronal, morphological palatalization threatens to produce stem-internal sequences like [t…tʃ], [t…dʒ], [t…ʃ] (as well as [s…tʃ], [t…ʃ], etc.). As described in greater detail in §2.4.1.2, such forms option-

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[21] A similar morpheme-internal ordering restriction on coronal plosives is found in Javanese (Malayo-Polynesian; Uhlenbeck 1949, Mester 1988b), with respect to dentals and retroflexes on the one hand and the so-called 'palatals' on the other. Uhlenbeck (1949) notes that while palatal…dental and palatal…retroflex sequences are quite common, their mirror images are rare. The statistical study of Javanese co-occurrence patterns undertaken by Mester (1988b) revealed that the facts are somewhat more complicated, but Mester nevertheless concludes that '[t]here are more combinatorial restrictions in the order coronal + palatal […] than the order palatal + coronal' (Mester 1988b:162). Though the 'palatal' plosives of Javanese are frequently analyzed as phonologically [+high] (e.g. by Mester 1988), they are phonetically *alveolar* affricates [ts, dz] (see Ladefoged & Maddieson 1996 and references cited there). If the ordering asymmetry in Javanese is connected to the Palatal Bias effect, then this can at most be true from a diachronic perspective rather than in synchronic terms.

ally undergo double palatalization, surfacing instead with [tʃ…tʃ] and the like. This can be seen in examples like those in (26).

(26) Harari: 'double palatalization' before 2SgFem /-i/ (Rose 2004)

2SgMasc	*2SgFem*	
bit'as	bitʃ'aʃ-i ~ bit'aʃ-i	'rip!'
t'imad	tʃ'imadʒ-i ~ t'imadʒ-i	'tie, be strongly against!'
sidab	ʃidʒab-i ~ sidʒab-i	'insult!'
kisas	kisaʃ-i ~ kiʃaʃ-i	'take to court!'

Note that the Harari case involves stop/affricate alternations ([t]~[tʃ], [t']~[tʃ'], [d]~[dʒ]) in addition to fricative alternations ([s]~[ʃ]). If coronal harmony were implicated in the double-palatalization facts seen in (26), that harmony would be consistent with the patterns found in the other languages discussed earlier in this section, both in terms of the directionality of assimilation and the Palatal Bias. However, the fact that the Harari alternations are morphologically driven, combined with the fact that they target sonorants as well as obstruents (see §2.4.1.2 for discussion) makes an interpretation along these lines somewhat dubious.

To sum up, Palatal Bias effects are found not only in the typology of sibilant harmony systems, but also in that of the much rarer type of coronal harmony in which alveolar stops and 'palatal' affricates interact. In both cases alveolars have a far stronger tendency to assimilate to a nearby palatal than vice versa. Insofar as this asymmetry mirrors the Palatal Bias that has been robustly demonstrated in speech error studies, it can be taken as strong circumstantial evidence that coronal harmony—and, by extension, consonant harmony in general—has its roots in the domain of speech planning.

6.5. Summary

This chapter has focused on the relationship between consonant harmony and the domain of speech planning, that is, phonological encoding for language production. In particular, several parallels have been pointed out between on-line production errors (slips of the tongue) and the phonological patterns and processes involved in consonant harmony. Some of these were already discussed in earlier chapters to a greater or lesser extent. One parallel is the great sensitivity of both consonant harmony and speech errors to the relative similarity of the interacting segments. Similarity effects of this kind are attested in coronal harmony systems no less than in other types of long-distance consonant assimilation. For example, sibilant harmony may hold only between fricatives (and thus not apply to fricative/affricate combinations), or it may hold only between fricatives that agree in voicing.

A second parallel is the default status of anticipatory directionality in consonant harmony, as demonstrated in §3.1, which has gone unnoticed in previous studies. Just as anticipatory assimilation is the norm in consonant harmony, so are anticipations far more prevalent in slips of the tongue than are perseverations. Although perseveratory errors do occur, they are associated more with relatively ‘dysfunctional’ states of the production system (e.g. in aphasics and young children) and are generally correlated with situations of elevated error rates (increased speech rate, unfamiliarity with the phrase being produced, etc.), whereas the same is not true of anticipatory errors.

The main purpose of this chapter was to document the existence of another striking parallel: the presence of a so-called ‘Palatal Bias’. In on-line production errors involving alveolar and ‘palatal’ (postalveolar) obstruents, alveolars tend to be replaced by palatals much more often than the reverse. This asymmetry has been documented in several corpora of naturally occurring slips of the tongue, and has been replicated in experimental studies of speech errors elicited in a laboratory setting. As demonstrated in §6.3, the Palatal Bias—or something equivalent to it—is directly reflected in the cross-linguistic typology of those sibilant harmony systems that involve a /s/ vs. /ʃ/ distinction. When there is any kind of asymmetry present in such systems, the favored assimilatory change is always /s/ → [ʃ] rather than /ʃ/ → [s]. The sole exception to the generalization, Tlachichilco Tepehua, shows that the preference of /s/ → [ʃ] over /ʃ/ → [s] cannot be elevated to a *synchronic* universal (e.g. in terms of fixed constraint rankings). However, it was argued in §6.3.3 that the typologically anomalous character of Tlachichilco Tepehua sibilant harmony may have something to do with the historical origins of that particular harmony system.

Finally, it was shown in §6.4 how, in addition to sibilant harmony, the Palatal Bias also manifests itself in the very rare subtype of coronal harmony where alveolar stops and ‘palatal’ affricates interact. In all attested harmony systems of this type, the alveolar stop is always the target, assimilating to a following affricate (/t…tʃ/ → [tʃ…tʃ]). This is again consistent with speech error findings: /t/ is considerably more likely to be replaced by /tʃ/ in slips of the tongue than vice versa. The fact that a Palatal Bias is manifested in the typology of phonological harmony processes of two distinct kinds—ones involving alveolar vs. palatal ‘stridents’ (fricatives and affricates) and ones involving alveolar stops vs. palatal affricates—makes it unlikely that the parallel between speech errors and consonant harmony is merely coincidental.

To sum up, the wide-ranging parallels that have been demonstrated to hold between slips of the tongue and the phonological processes of consonant harmony provide strong support for the hypothesis that the latter has its roots (diachronic and/or synchronic) in the speech planning domain. This hypothesis provides the functional foundation for the synchronic analysis of consonant harmony as featural *agreement* (as opposed to feature/gesture *spreading*) as laid out in chapters 4 and 5.

7. SUMMARY AND CONCLUSIONS

In the preceding chapters I have presented an analysis of consonant harmony as *agreement*, based on a comprehensive typological investigation into the phonological characteristics and cross-linguistic variation of consonant harmony patterns in the world's languages. A key ingredient in the proposal has been that consonant harmony—including its most canonical manifestation, coronal (sibilant) harmony—has its sources in the domain of speech planning, or phonological encoding for speech production (cf. Rose & Walker 2004). I have defended this view by pointing out a great number of striking parallels between consonant harmony processes on the one hand and phonological slips of the tongue on the other, many of which had not been noted in the literature on consonant harmony prior to the appearance of the dissertation which underlies this monograph (Hansson 2001b).

The empirical foundation of this study was a survey of attested consonant harmony phenomena in the world's languages, drawing on a database consisting of approximately 170 distinct cases. The results of this survey were presented in chapters 2 and 3. Most of the individual cases were mentioned in chapter 2, along with citations of relevant descriptive sources (and analytical works, where appropriate), and many were explicitly described and illustrated with examples. It is my hope that this detailed overview, and the data and bibliographic references contained in it, will serve as a useful 'encyclopedic' resource for future research on consonant harmony and related topics. It is certainly the most comprehensive survey of such phenomena that has appeared to date. To this end, chapters 2 and 3 were given a primarily empirical-descriptive focus, with patterns and generalizations stated in a way which was meant to transcend differences between theoretical frameworks (to the extent this is possible).

The main conclusion to draw from the survey in chapter 2 is that consonant harmony systems are remarkably varied in terms of the phonetic-phonological properties that can be subject to long-distance assimilation. As had been noted in earlier works (Shaw 1991, Gafos 1999), coronal harmony—and sibilant harmony in particular—is the most widely attested type of consonant harmony by far. This kind of harmony involves certain coronal-specific distinctions that could be characterized as 'minor' place of articulation. But a wide range of other features may form the basis of consonant harmony interactions. For example, consonants may agree in secondary-articulation features (pharyngealization, velarization, palatalization), dorsal consonants may agree in 'uvularity', liquids may agree in laterality/rhoticity (and possibly the tap/non-tap distinction) and glides may agree with liquids (or vice versa). With respect to nasality, voiced obstruents may interact with full nasals or with prenasalized (voiced) obstruents, or full nasals and prenasalized consonants may interact amongst themselves; alternatively, oral approximants (liquids and/or glides) may interact with nasals. Obstruents may agree in one or more laryngeal features (voicing, aspiration, glottalic vs. pulmonic airstream mechanism); often the interaction is limited to obstruents which already agree in place or manner of articulation (or both). Finally, consonants may agree in stricture ([±continuant]), with fricatives—and possibly even sonorants—interacting with stops and/or affricates.

In sum, there are very few properties that are never involved in the kinds of long-distance assimilation that qualify as consonant harmony. A glaring exception is major place of articulation, a fact which has been accorded great significance in many earlier works (e.g. Ní Chiosáin & Padgett 1997, Gafos 1999). The absence of major-place harmony is certainly significant, and has yet to be fully explained (given that such phenomena as stricture harmony *do* exist). However, it is possible that this unattested phenomenon is simply at the far end of a gradient scale of decreasing frequency of occurrence. For example, although stricture harmony does occur, it is exceedingly rare cross-linguistically. Laryngeal harmony, though quite common as a root-internal co-occurrence restriction, hardly ever reaches across morpheme boundaries. Note that major place is often subject to root-internal co-occurrence restrictions, but these are then always *dissimilatory* rather than assimilatory. The apparent absence of major-place harmony might be due to a bias in favor of place dissimilation over assimilation, rather than an inherent impossibility of this phenomenon. Whatever their explanation may be, such biases are found for other harmony types as well. For example, long-distance liquid interactions ([l] vs. [r]) involve dissimilation or metathesis far more often than assimilation. Conversely, long-distance sibilant interactions (e.g. [s] vs. [ʃ]) are hardly ever dissimilatory; instead, harmony is the norm.

Even though consonant harmony can be based on a highly diverse set of features, a major finding of this study is that attested consonant harmony systems are remarkably uniform with respect to a number of properties. Of these, three major ones were discussed in chapter 3. The first is a strong directionality bias: consonant harmony processes strongly tend to involve anticipatory (regressive, right-to-left) assimilation. Where perseveratory (progressive) assimilation occurs, this can almost always be explained as a by-product of stem control, where the direction of assimilation is governed by morphological constituent structure, or occasionally as due to a kind of 'dominance', where only one feature value (typically the marked one) triggers assimilation. Secondly, consonant harmony is almost never affected by segmental opacity, where a specific class of intervening segments blocks the propagation of the harmonic feature. Instead, the norm is for any segmental material separating the trigger and target consonants to be consistently irrelevant, and thus 'transparent' to the interaction taking place across it. Thirdly, consonant harmony is never influenced in any way by prosodic factors such as stress or syllable weight, and is never bounded by prosodically-defined domains like the metrical foot. Overall, the typological profile that characterizes consonant harmony systems is quite distinctive, especially with regard to segmental opacity effects and sensitivity to prosodic structure, both of which are extremely frequent in vowel harmony and vowel-consonant harmony but absent (or nearly so) for consonant harmony.

Based on the empirical generalizations of chapters 2 and 3, a generalized formal analysis of consonant harmony was developed in chapters 4 and 5, couched in Optimality Theory, an output-oriented and constraint-based framework of generative phonology. The core of the analysis is the idea that consonant harmony is due to *agreement*, which is itself dependent on (string-internal) correspondence relations between highly similar output segments. The analysis is based on the Agreement by Correspondence (ABC) model developed by Walker (2000a, 2000c, 2001) and Rose & Walker (2000, 2004). In the version of the ABC model proposed here, the default status of anticipatory directionality has been built directly into the correspondence relation itself ($C_1 \leftarrow C_2$), with perseveratory harmony (e.g. under stem control) emerging as a by-product of constraint interaction. Nevertheless, deriving absolute directionality proves to be challenging, due in large part to the output-oriented nature of phonological derivations in Optimality Theory. This problem has been solved here by further proposing that the agreement constraints that enforce harmony are *targeted* constraints (Wilson 2000, 2001, 2003, 2006; see also Baković & Wilson 2000).

Given these assumption, the framework was shown to be able to deal not only with the basic directionality patterns, but also with more intricate effects resulting from the interplay of harmony with various other constraints on markedness and phonotactic distribution. At the end of chapter 5, I highlighted certain potentially problematic aspects of the ABC, pointing out particular phenomena that it may be unable to handle. The tentative conclusion was drawn that the notion of string-internal correspondence might eventually need to be abandoned, in favor of a simpler model where the function of the similarity-scaled CORR-C↔C constraints and the harmony-inducing (targeted) $\rightarrow$IDENT[F]-CC constraints would be conflated into a single constraint type. The exploration of the details and implications of this alternative approach are left to future investigation, but the result would be somewhat reminiscent of the kinds of 'anti-disagreement' constraints advocated (primarily for vowel harmony) by Pulleyblank (2002).

Finally, chapter 6 adduced further empirical evidence in support of the claim that consonant harmony interactions are rooted in the speech planning domain. I pointed out a number of parallels between consonant harmony processes and phonological speech errors. These include not only the pervasive similarity effects noted by Rose & Walker (2000, 2004), whereby similar segments interact much more frequently than less similar ones (see Frisch 1996), but also the predominance of anticipatory directionality, as well as the inertness and irrelevance of segmental material separating the interacting consonants. Yet another striking parallel was discussed at length, which had not been noticed prior to Hansson (2001a, 2001b), namely the existence of so-called 'palatal bias' effects in the cross-linguistic typology of coronal harmony systems. This effect, along with its well-documented counterpart in the domain of speech errors, was discussed in detail in chapter 6, illustrated with examples from a variety of languages.

The view of consonant harmony that has been argued for in the preceding chapters, and the formal analysis implemented here and in related works (especially Rose & Walker 2004), has the potential of shedding new light on the relationship between consonant harmony patterns in adult languages and the analogous long-distance (or at least 'transvocalic') consonant assimilations that are rampant in child language (Smith 1973, Ingram 1974, Vihman 1978, Stoel-Gammon & Stemberger 1994, Goad 1997, Bernhardt & Stemberger 1998, Berg & Schade 2000, Pater & Werle 2001, 2003). The fact that consonant harmony in child language most typically involves major place of articulation—a pattern which is generally claimed to be unattested in adult language—has often led phonologists to conclude that this phenomenon must be fundamentally distinct from consonant harmony in adult languages (Ní Chiosáin & Padgett 1997, Gafos 1999). However, viewing consonant harmony as long-distance agreement, grounded in the domain of phonological encoding for speech production and triggered by relative similarity, puts this issue in a fresh perspective. At the developmental stage when major-place harmony most frequently occurs (most typically late in the second year), the segmental inventory available to the child is considerably impoverished. Consequently, major place of articulation is presumably far less entrenched as a systematic parameter of lexical contrast than it is in an adult's grammar. In her detailed survey of consonant harmony in child language, Vihman (1978:324) addresses the relationship between this phenomenon and adult consonant harmony, and draws the following parallel:

> It may be that *s* - *š* (and other combinations of the alveolar and palato-alveolar fricatives) represent, for adults, the same kind of difficulty that *p* - *t*, *t* - *k*, etc. apparently present for children.

It should also be emphasized that consonant harmony in child language can involve properties other than major place of articulation. In such cases, the resulting pattern often has a clear parallel in adult languages. For example, harmony may take the form of nasal consonant harmony (e.g. [minz] for *beans*), or even that most canonical type of consonant harmony, sibilant harmony involving the [s] vs. [ʃ] distinction. An example of the latter is found in the (French) speech of Suzanne, as reported by Deville (1891) and analyzed by Berg & Schade (2000), as seen in words like *chausser* /ʃoseː/ 'to put on (shoes)' → [ʃoːʃeː] ~ [soːseː].

The similarity-based agreement analysis developed in the preceding chapters may help explain the differences between child and adult consonant harmony. It is reasonable to assume that in early stages, when the inventory is small and major-place distinctions are closer to the limits of the child's phonological capabilities, pairs like [t] vs. [k] are judged (by the child) to be far more similar than they would be for an adult. Consequently, they should be more likely to enter into the kinds of similarity-based relations that generate consonant harmony interactions in adult language. As the consonant inventory grows, contrasts that have been mastered earlier (such as major-place distinctions) become more entrenched than those which are acquired later, such as the 'minor-place' contrast between [s] and [ʃ], and less likely to give rise to agreement effects.[1] This might explain why major-place harmony is so common in child language but unattested in adult language.

There are certain other parallels between consonant harmony in child and adult language that suggest that also suggest that these two phenomena are homologous. For example, as noted in chapter 6, the predominance of anticipatory directionality is also strongly characteristic of child consonant harmony, as repeatedly noted in the acquisition literature (Menn 1971, Smith 1973, Cruttenden 1978, Vihman 1978, Stoel-Gammon & Stemberger 1994, Bernhardt & Stemberger 1998, Pater & Werle 2001, 2003). Nevertheless, some differences may also exist. For instance, Rose (2000) argues that differences between harmony patterns displayed by French and English learners are due to the different prosodic structures of the two target languages. Recall from chapter 3 that adult consonant harmony processes are never sensitive to prosodic structure in any way; this divergence is therefore somewhat surprising. A more detailed and systematic comparison of the consonant harmony effects attested in acquisition and in adult grammars would undoubtedly help further our understanding of each of these two phenomena.

Setting aside the question of consonant harmony in child language, some words of caution are in order with respect to the claim, stated above, that consonant harmony is motivated in (or 'has its roots in') the domain of speech planning. Elsewhere in this work, it was suggested that consonant harmony patterns could be regarded, loosely speaking, as 'phonologized speech errors'. This suggestion should not be taken too literally. Given how rare errorful productions of a given word is, as compared to productions without error, it seems rather unlikely that sporadic on-line errors would be able to spawn *regular* sound changes, yielding completely systematic and exceptionless phonological patterns that hold true for the entire lexicon. I suggested at the end of chapter 2 that the actual diachronic origins of the individual sound patterns surveyed here may turn out to be quite diverse—a point which I have argued at greater length elsewhere (Hansson 2004a, 2007c). If so, this makes the relative uniformity of the collective typological profile of consonant harmony patterns (in terms of their *synchronic* properties) all the more interesting. If cognitive factors of planning and phonological encoding are implicated in the patterning of consonant harmony phenomena, as I have argued here, then this link must hold at a relatively grammaticalized level.

While the precise nature of the link between speech planning and phonological consonant harmony is yet to be worked out, it is worth noting that the same (or at least similar) questions

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[1] Berg (1992) and Berg & Schade (2000) develop an analysis of consonant harmony in child language based on spreading activation in a connectionist network model, where harmony most often results from particular links in the network being impoverished (resulting in a hypo-activation effect). It would be interesting to see if it is feasible to approach consonant harmony in adult language in a similar manner, though this raises thorny questions about the relationship between competence and performance and the status of phonologized sound patterns.

arise for of other types of sound patterns. For example, Frisch (1996) and Frisch et al. (1997, 2004) argue convincingly that the dissimilatory OCP[Place] restrictions on roots in Arabic are governed by a similarity metric of precisely the same kind as that which manifests itself in phonological slips of the tongue, and that the kinds of consonant combinations that are being avoided are ones which are particularly difficult to process in production, perception, recognition and lexical retrieval. However, the question remains how these systematic dissimilatory patterns came into existence in the first place—that is, precisely *how* Arabic (or its Proto-Semitic or Proto-Afro-Asiatic ancestor) came to 'phonologize' the similarity-based dispreference for certain consonant co-occurrences. Frisch et al. (2004:221) suggest that the development of such patterns is gradual, with processing factors shaping the lexicon—and thereby the phonological grammar (e.g. phonotactic generalizations)—over time, as more 'difficult' structures will be disfavored in acquisition, borrowing, coining of novel forms, and active usage (and hence also in the ambient input which the next generation of learners will draw upon). This view receives support by studies of lexical evolution. For example, Martin (2007) demonstrates that OCP-violating liquid sequences (/…lVl…/, /…ɹVɹ…/) are not only statistically underrepresented in the English lexicon—and have been so ever since the Old English period—but also consistently disfavored in the coining of neologisms (e.g. drug brand names, novel baby names, names for fantasy role-playing game characters).

While this is a plausible explanation for many attested morpheme-internal co-occurrence restrictions, including a great number of the consonant harmony cases surveyed here, it is not entirely sufficient. For one thing, it does not provide a fully satisfactory account for those root-internal co-occurrence patterns that are *categorical* (i.e. exceptionless, or nearly so), and which are actively enforced by triggering overt *repair* in items which violate the generalization (e.g. as a result of borrowing, reanalysis of morphologically complex words, or due to the effects of other regular sound changes). It appears that at some point in the diachronic process a certain Rubicon gets crossed, such that the 'difficult' structures in question go from being simply rare in the lexicon, and disfavored in usage, to being actively altered. When and how is this watershed reached? This important question, which is of fundamental importance for the more general issue of how gradient sound patterns relate to categorical ones, and to the phonological grammar (Coetzee & Pater 2008a), has not been addressed directly in the literature, to the best of my knowledge.

A second important and as-yet-unanswered question concerns the relationship between morpheme-internal co-occurrence restrictions (including consonant harmony) and ones which are enforced over morphologically complex structures as well and hence trigger alternations in the surface shape of morphemes. Rose & Walker (2004:489) suggest that consonant harmony patterns which originate root-internally might be subject to a kind of analogical extension; they conjecture that 'in circumstances where affixation forms words containing consonant combinations excluded within morphemes, the condition could be extended by analogy within a language to operate over the entire word' (see also Hansson 2004a, 2007c). However, the mechanisms by which such extension might take place are not well understood. An promising line of inquiry in this area concerns the kinds of 'leakage' effects documented by

Martin (2007), where categorical domain-restricted phonotactic patterns tend to be mirrored by weaker, gradient effects across domain boundaries—such as where compound words in Turkish or Navajo show a statistical tendency not to be disharmonic ('by accident', as it were) despite the fact that Turkish vowel harmony and Navajo sibilant harmony are not enforced across a compound boundary. Martin (2007) hypothesizes that 'leakage' of this kind is a by-product of certain design properties of the learning algorithm he adopts (the maximum entropy learner of Hayes & Wilson 2008). It is conceivable that something along these lines might provide a vehicle by which morpheme-internal harmony spawns alternations in heteromorphemic contexts. However, research in this area is still in its infancy, and it is premature to conclude anything definitive about the feasibility of this account.

Another research area where the typology of consonant harmony systems is likely to play an active role in the future is the question of *learnability* of phonotactic patterns and phonological grammars, and in particular the impact that *(non-)locality* of segmental interactions has on learnability. The problem is particularly acute for learning models which take the constraint set to be constructed by the learner (rather than predetermined by some innate Universal Grammar module), such as that of Hayes & Wilson (2008). As Hayes & Wilson note, the capability of discovering long-distance dependencies requires a dramatic increase of the search space, severely threatening the computational feasibility of the learning task, unless such apparently non-local relations are somehow rendered effectively local, for example by means of 'projection' of the relevant segment types (though see Hayes & Wilson 2006:426 for practical problems in that regard, with respect to consonant harmony in particular). Even then, sound patterns which require a distinction between transparent and opaque interveners pose an effectively intractable problem. Heinz (2007, 2008) takes comfort in the typological claim, asserted in Hansson (2001b) and Rose & Walker (2004), that long-distance consonant assimilations are *never* subject to segmental opacity. On this assumption, the precedence learner that Heinz proposes constitutes a good typological fit, as it is able to capture the attested kinds of long-distance phonotactic dependencies but is crucially incapable of learning such patterns if blocking is involved. However, the recent discovery of blocking effects in certain consonant harmony systems (Rwanda, Imdlawn Tashlhiyt Berber; see §3.2.2.2 above), and the fact that local spreading may provide the *means* to achieve long-distance agreement, shows that the learnability problem is far from being settled.

For these and other reasons, consonant harmony phenomena are likely to continue to provide a rich source of challenging problems and test cases for phonological theory. These intriguing sound patterns bear in important ways on hypotheses about aspects of phonological structure and knowledge (representations, constraints, constraint interaction, interfaces with phonetic implementation and morphological structure), the acquisition of such knowledge (learnability, the relationship between child and adult grammars), phonological typologies and the factors that shape them (mechanisms of diachronic change, learning biases, innate cognitive constraints), and the grounding of phonological patterns in functional aspects of language use (production, perception, processing). At the same time, continued descriptive, analytical and instrumental work is certain to expand our empirical knowledge base of consonant harmony phenomena, adding new cases and revealing additional details about previously documented cases, and almost certainly contributing new generalizations as well as challenging or contradicting previous ones. In short, research into these kinds of long-distance interaction will continue to be a fruitful research area for many years to come.

Appendix: Consonant Harmony Database

The following lists all of the individual cases included in the database on which the typological survey is based. For reasons of space, only a minimal amount of information can be provided on each entry. The genetic affiliation and geographic location of each language or dialect is provided, and descriptive and/or analytical references are cited. For languages spoken in Canada, the U.S.A. or Mexico, the location is given in terms of the relevant state, province or territory (e.g., British Columbia, California, Veracruz); otherwise only the (main) country names are provided. The individual harmony patterns are categorized in accordance with the classification used in §2.4, usually with some further information on the class(es) of consonants involved in the harmony. In addition, each case is labelled with respect to whether it operates solely as a 'static' morpheme structure constraint (MSC) on roots or is manifested 'actively' in the form of alternations, or both. Discussion of individual cases in the main text can be located with the help of the Language Index provided on pp. 417–422 below.

Aari (Omotic; Ethiopia) [Hayward 1988, 1990a]
coronal harmony (sibilants) MSC + alternations

Adhola (Nilotic; Uganda) [Heusing 2004]
coronal harmony (stops) MSC

Alur (Nilotic; Uganda, D.R.C.) [Knappert 1963, Burssens 1969, Tucker 1969, Mester 1988b, Heusing 2004]
coronal harmony (stops) MSC

Amharic (Semitic; Ethiopia) [Rose & King 2007]
laryngeal harmony (plosives; gradient) MSC

Anywa (Nilotic; Sudan, Ethiopia) [Reh 1996, Rose & Walker 2004, Mackenzie 2005]
coronal harmony (stops, nasals) MSC + alternations

Apache, Chiricahua (Athapaskan; New Mexico, Oklahoma) [Hoijer 1946]
coronal harmony (sibilants) MSC + alternations

Apache, Plains (Kiowa) (Athapaskan; Oklahoma) [Bittle 1963]
coronal harmony (sibilants) MSC + alternations

Apache, Western (Athapaskan; Arizona) [de Reuse & Goode 2006]
coronal harmony (sibilants) MSC + alternations

Arabic, Libyan (Semitic; Libya) [Abumdas 1985]
coronal harmony (sibilants) MSC?

Arabic, Moroccan (Semitic; Morocco) [Harris 1944, Harrell 1962, Heath 1987, 2002]
coronal harmony (sibilants) MSC

Atsugewi (Palaihnihan; California) [Talmy 1972, Good 2004]
liquid harmony (lateral *vs.* rhotic) MSC + alternations

Aymara, 'Bolivian' (Aymaran; Bolivia) [de Lucca 1987, MacEachern 1999]
coronal harmony (stops *vs.* affricates) MSC
dorsal harmony (obstruents) MSC
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC

Aymara, 'Peruvian' (Aymaran; Peru) [Ayala Loayza 1988, Deza Galindo 1989, MacEachern 1999]
laryngeal harmony (plosives) MSC
major-place harmony (ejectives, aspirates) MSC

Barbareño; *see* Chumash

Basaa (Bantu; Cameroon) [Greenberg 1951, Lemb & de Gastines 1973]
liquid harmony (lateral *vs.* glide) alternations (one affix)
nasal consonant harmony? MSC + alternations

Basque, High Navarrese (Baztan) dial. (isolate; Spain) [Salaburu 1984, Hualde 1991, Clements 2001]
coronal harmony (sibilants; 3-way contrast) MSC

Basque, various diall. (isolate; Spain) [Michelena 1985, 1995, Hualde 1991, Trask 1997]
coronal harmony (sibilants) MSC

Beaver; *see* Dane-zaa

Bemba (Bantu; Zambia) [Hyman 1995, Kula 2002]
nasal consonant harmony MSC + alternations

Benchnon (Gimira) (Omotic; Ethiopia) [Hayward 1988, Breeze 1990, Rapold 2006]
coronal harmony (sibilants, 3-way contrast) MSC + alternations

Berber; *see* Siwi, Tashlhiyt, Tamazight, Tuareg

Bole (Chadic; Nigeria) [Schuh 2002, Riggle & Wilson 2004]
coronal harmony (sibilants) (free variation)

Bukusu (Bantu; Kenya) [de Blois 1975, Odden 1994, CBOLD database]
liquid harmony (lateral *vs.* rhotic) MSC + alternations

Bungee; *see* English

Capanahua (Panoan; Peru) [Loos 1967]
coronal harmony (sibilants; 3-way contrast) MSC

Chaha (Semitic; Ethiopia) [Leslau 1979, Banksira 2000, Rose & Walker 2004, Rose & King 2007]
laryngeal harmony (plosives) MSC

Chilcotin; *see* Tsilhqot'in

Chiricahua Apache; *see* Apache

Chol (Mayan; Chiapas) [Gallagher 2008, Gallagher & Coon 2009]
coronal harmony (sibilants) MSC
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC
stricture harmony (sibilant fricatives *vs.* affricates) MSC

Chontal (Mayan; Tabasco) [Keller 1959, McCarthy 1989]
major-place harmony? (ejectives) MSC

Chumash, Barbareño (Chumashan; California) [Beeler 1970, Mithun 1998]
coronal harmony (sibilants) MSC + alternations

Chumash, Ineseño (Chumashan; California) [Applegate 1972, Poser 1982, 1993, 2004, Kiparsky 1993, McCarthy 2006]
coronal harmony (sibilants) MSC + alternations
dorsal harmony? (gradient/historical?) MSC

Ventureño (Chumashan; California) [Harrington 1974, Mamet 2005]
coronal harmony (sibilants) MSC + alternations

Coptic, Bohairic dial. (Egyptian; Egypt) [Chaine 1933, Till 1961, Westendorff 1977]
coronal harmony (sibilants) MSC

Coptic, Sahidic dial. (Egyptian; Egypt) [Chaine 1933, Till 1961, Westendorff 1977]
coronal harmony (sibilants) MSC

Dane-zaa (Beaver), Doig River dial. (Athapaskan; Alberta, British Columbia) [Story 1989]
coronal harmony (sibilants; 3-way contrast) MSC + alternations

Dene-tha (Slave), Bearlake dial. (Athapaskan; Northwest Territories) [Rice 1989]
coronal harmony (sibilants) MSC + alternations

Dime (Omotic; Ethiopia) [Seyoum 2008]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (voicing) alternations

English, Bungee (Germanic; Manitoba) [Blain 1989]
coronal harmony (sibilants) (free variation)

English, Papua New Guinean (Germanic; Papua New Guinea) [Crowley 1997:58]
coronal harmony (sibilants) MSC + alternations?

Fang (Bantu; Equatorial Guinea; Cameroon) [Greenberg 1951]
nasal consonant harmony MSC? (alternations levelled)

Flemish, Teralfene dial. (Germanic; Belgium) [Willem de Reuse, pers. comm.]
coronal harmony (sibilants) MSC + alternations

French, Métis dial. (Romance; Manitoba, N. Dakota) [Papen 1984, Douaud 1985, Bakker & Papen 1996]
coronal harmony (sibilants) MSC (free variation?)

Gaagudju (Arnhem Land; Australia) [Hamilton 1993, Gafos 1999]
coronal harmony (apical stops, nasals, laterals) MSC (position-sensitive)

Ganda (Bantu; Uganda) [Katamba & Hyman 1991]
nasal consonant harmony MSC

Georgian, Old (Kartvelian; Georgia) [MacEachern 1999]
laryngeal harmony (stops) MSC

Gitksan (Tsimshianic; British Columbia) [Brown 2008, Brown & Hansson 2008]
dorsal harmony (gradient) MSC
laryngeal harmony (plosives, gradient) MSC

Gimira; *see* Benchnon

Gojri (Indo-Aryan; India, Pakistan) [Sharma 1979, MacEachern 1997]
laryngeal harmony (stops) MSC
major-place harmony? (aspirates) MSC

Gooniyandi (Bunuban; Australia) [McGregor 1990, Steriade 1995a, 1995b, Gafos 1999]
coronal harmony (apical stops, nasals, laterals) MSC (position-sensitive)

Gude (Chadic; Nigeria, Cameroon) [Hoskison 1974, 1975, Schuh 2002, Tsang 2007]
coronal harmony? (sibilants) alternations (featural affixation)

Harari (Semitic; Ethiopia) [Leslau 1958, Rose 1997, 2004]
coronal harmony? (sibilants; stops *vs.* affricates) alternations (featural affixation)

Hausa (Chadic; Nigeria, Niger, Benin) [Parsons 1970, MacEachern 1999, Newman 2000]
laryngeal harmony (stops) MSC
liquid harmony (lateral *vs.* rhotic) MSC
major-place harmony? (ejectives, implosives) MSC
nasal consonant harmony MSC

Herero (Bantu; Namibia, Botswana) [Booysen 1982]
nasal consonant harmony MSC + alternations

Hupa (Athapaskan; California) [Golla 1970]
coronal harmony (sibilants) MSC + alternations

Ijo, Kalabari (Niger-Congo; Nigeria) [Jenewari 1989]
laryngeal harmony (plosives) MSC

Ila (Bantu; Zambia) [Greenberg 1951]
nasal consonant harmony MSC + alternations

Ineseño; *see* Chumash

Ixil, Nebaj dial. (Mayan; Guatemala) [Ayres 1991]
coronal harmony (sibilants; 3-way contrast) MSC (+ alternations?)

Izere (Plateau; Nigeria) [Blench & Kaze 2000, Blench 2001, Hyman 2006]
coronal harmony (sibilants) MSC + alternations
nasal consonant harmony MSC (+ alternations, historically)

Izon, Bumo (Niger-Congo; Nigeria) [Efere 2001, Mackenzie 2005]
laryngeal harmony (stops) MSC

Javanese (Malayo-Polynesian; Indonesia, Malaysia) [Uhlenbeck 1949, 1950, Mester 1988b, Yip 1989]
coronal harmony? (stops) MSC
liquid harmony? (lateral *vs.* rhotic) MSC

Karaim, Northwest dial. (Turkic; Lithuania) [Kowalski 1929, Jakobson et al. 1963, Musaev 1964, Nevins & Vaux 2003, Denwood 2005, Hansson 2007c]
secondary-articulation harmony MSC + alternations

Kera (Chadic; Chad, Cameroon) [Ebert 1979, Odden 1994, Walker 2000a, Hansson 2004a, Pearce 2006, 2009]
coronal harmony (stops *vs.* affricates) MSC + alternations
laryngeal harmony? MSC + alternations

Kalabari; *see* Ijo

Kalasha (Indo-Aryan; Pakistan) [Arsenault & Kochetov 2008, 2009]
coronal harmony (sibilants, stops; 3-way contrast) MSC

Kiga; *see* Nkore-Kiga

Kiowa Apache; *see* Apache, Plains

Komi-Permyak (Finno-Ugric; Russia) [Kochetov 2007; cf. Kochetov & Lobanova 2007]
coronal harmony (sibilants; gradient) MSC

Kongo (Bantu; D.R.C., Angola, Congo) [Ao 1991, Odden 1994, Piggott 1996, Rose & Walker 2004]
nasal consonant harmony MSC + alternations

Koyra (Omotic; Ethiopia) [Hayward 1982, 1988, Ford 1990]
coronal harmony (sibilants) MSC + alternations

Kukuya (Bantu; Congo) [Paulian 1975, Hyman 1987, 2006]
nasal consonant harmony MSC

Kwanyama (Bantu; Angola, Namibia) [Meinhof 1932]
nasal consonant harmony MSC + alternations

Lamba (Bantu; Zambia) [Doke 1938, Odden 1994, Piggott 1996]
nasal consonant harmony MSC + alternations

Luba (Bantu; D.R.C.) [Johnson 1972, Howard 1973]
nasal consonant harmony MSC + alternations

Luo (Nilotic; Kenya) [Yip 1989, Tucker 1994, Padgett 1995, Heusing 2004, Mackenzie 2005]
coronal harmony (stops) MSC

Maale (Omotic; Ethiopia) [Amha 2001]
coronal harmony (sibilants) MSC + alternations

Mafa (Chadic; Cameroon, Nigeria) [Barreteau & Le Bleis 1990, Ettlinger 2004]
coronal harmony? (sibilants) alternations (featural affixation)

Malto (Dravidian; India, Bangladesh) [Mahapatra 1979]
coronal harmony (stops) MSC

dorsal harmony (obstruents) MSC
laryngeal harmony (dorsals) MSC

Mayak (Nilotic; Sudan) [Andersen 1999]
coronal harmony (stops) MSC + alternations

Mayali (Gunwinyguan; Australia) [Evans 1995, 2003]
coronal harmony (apical stops, nasals) MSC?

(Ki)Mbundu (Bantu; Angola) [Chatelain 1888–1889]
nasal consonant harmony MSC + alternations

Michif (mixed language; Manitoba, North Dakota) [Bakker 1996, Bakker & Papen 1996]
coronal harmony (sibilants) MSC (free variation?)

Misantla Totonac; *see* Totonac

Miya (Chadic; Nigeria) [Schuh 1998, 2002]
coronal harmony? (sibilants) alternations (featural affixation)

Mokilese (Oceanic; Federated States of Micronesia) [McCarthy 1989]
secondary-articulation harmony (labials) MSC

Moroccan Arabic; *see* Arabic

Murrinh-patha (isolate?; Australia) [Street & Mollinjin 1981, Steriade 1995a]
coronal harmony (apical stops, nasals) MSC (position-sensitive)

Mwiini (Bantu; Somalia) [Kisseberth & Abasheikh 1975]
liquid harmony (lateral *vs.* rhotic; tap *vs.* non-flap) alternations

Navajo (Athapaskan; Arizona, New Mexico) [Sapir & Hoijer 1967, Kari 1976, Halle & Vergnaud 1981, McDonough 1990, 1991, 2003, Faltz 1998, Martin 2004, 2007]
coronal harmony (sibilants) MSC + alternations

Ndebele, Zimbabwean (Bantu; Zimbabwe, Botswana) [Pelling 1971, Hyman 1999a, Hansson 2004a, Sibanda 2004]
coronal harmony (clicks) MSC
laryngeal harmony (stops) MSC

Ndonga (Bantu; Namibia, Angola) [Viljoen 1973, Tirronen 1986]
nasal consonant harmony MSC + alternations

Ngbaka (Adamawa-Ubangi; D.R.C., Congo) [Thomas 1963, Mester 1988b, Sagey 1990, Walker 2000b, 2000c]
laryngeal harmony (stops) MSC
nasal consonant harmony MSC

Ngizim (Chadic; Nigeria) [Schuh 1978, 1997]
laryngeal harmony (obstruents) MSC

Nkore-Kiga (Bantu; Uganda) [Taylor 1959, Hyman 1999b]
coronal harmony (sibilants) MSC + alternations (allophonic)

Nyangumarta (Pama-Nyungan; Australia) [Hoard & O'Grady 1976]
nasal consonant harmony alternations (limited)

Paiute; *see* Southern Paiute

Paiwan (Austronesian; Taiwan) [Blust 1995]
coronal harmony (sibilants; stricture harmony?) historical sound changes (sporadic)

Pangwa (Bantu; Tanzania) [Stirnimann 1983]
nasal consonant harmony MSC + alternations

Pare (Bantu; Tanzania) [Odden 1994]
liquid harmony (liquid *vs.* glide) alternations
stricture harmony? (palatals) alternations

Päri (Nilotic; Sudan) [Andersen 1988]
coronal harmony (stops, nasals) MSC + alternations

Pengo (Dravidian; India) [Burrow & Bhattacharya 1970]
coronal harmony (plosives) MSC

Pohnpeian (Oceanic; Federated States of Micronesia) [Rehg & Sohl 1981, Mester 1988a, 1988b, Hansson 2007c]
secondary-articulation harmony (labials) MSC
coronal harmony? (stops) MSC
liquid harmony? (lateral *vs.* rhotic) MSC

Proto-Athapaskan-Eyak (reconstructed; Alaska?) [Krauss 1964]
coronal harmony (sibilants) MSC

Proto-Bantu (reconstructed; Nigeria/Cameroon?) [Larry M. Hyman, pers. comm.]
nasal consonant harmony? MSC

Proto-Omotic (reconstructed; Ethiopia?) [Hayward 1988]
coronal harmony (sibilants; 3-way contrast) MSC

Quechua, Southern Peruvian, colonial period (Quechuan; Peru) [Mannheim 1988, 1991]
coronal harmony (sibilants) MSC

Quechua, Southern Peruvian, modern (Quechuan; Peru) [Mannheim 1991]
dorsal harmony MSC

Quechua, Wanka (Quechuan; Peru) [Cerrón-Palomino 1977, Mannheim 1988]
coronal harmony (sibilants) MSC

Rumsen (Costanoan; California) [Garrett 1999, based on Miller 1999]
coronal harmony (sibilants) (MSC? +) alternations

Rundi (Bantu; Burundi, Uganda) [Meeussen 1959, Ntihirageza 1993]
coronal harmony (sibilants) MSC + alternations

Russian, various diall. (Slavic; Russia) [Kochetov & Radišić 2008]
coronal harmony (sibilants) historical sound changes (sporadic)

Rwanda (Bantu; Rwanda, Burundi) [Kimenyi 1979, Mpiranya & Walker 2005, Walker & Mpiranya 2005, Walker et al. 2008]
coronal harmony (sibilants) MSC + alternations (with blocking)

Saisiyat (Austronesian; Taiwan) [Blust 1995]
coronal harmony (sibilants; stricture harmony?) historical sound changes (sporadic)

Sanskrit, Vedic (Indo-Aryan; India) [Wackernagel 1896, Whitney 1889, MacDonell 1910, Allen 1951, Schein & Steriade 1986, Ní Chiosáin & Padgett 1997, Gafos 1999]
coronal harmony? (nasals *vs.* continuants) MSC + alternations

Sarcee; *see* Tsuut'ina

Sawai (Austronesian; Indonesia) [Whistler 1992]
nasal consonant harmony alternations

Siwi (Berber; Egypt) [Vycichl 2005]
coronal harmony (stops *vs.* affricates) MSC + alternations?

Slave; *see* Dene-tha

Shambaa (Bantu; Tanzania) [Roehl 1911, Besha 1989, Odden 1994]
coronal harmony? (sibilants) alternations?
stricture harmony? alternations (1 suffix)

Shilluk (Nilotic; Sudan) [Gilley 1992]
coronal harmony (stops, nasals) MSC + alternations

Suku (Bantu; D.R.C.) [Piper 1977]
nasal consonant harmony MSC + alternations

Southern Paiute (Uto-Aztecan; Utah, Arizona, Nevada) [Lovins 1972]
sibilant harmony MSC + alternations?

Sundanese (Austronesian; Indonesia) [Robins 1959, Cohn 1992, Holton 1995, Suzuki 1998, 1999, Curtin 2001
liquid harmony (lateral *vs.* rhotic) alternations (1 infix)

Tahltan (Athapaskan; British Columbia) [Hardwick 1984, Nater 1989, Shaw 1991, Halle 1995, Gafos 1999, Clements 2001, Levi 2004]
coronal harmony (sibilants, dentals; 3-way) MSC + alternations

Tanana, Lower (Athapaskan) [Tuttle 1998]
sibilant harmony MSC + alternations

Tamazight, various diall. (Berber; Morocco) [Laoust 1918, Willms 1972, Penchoen 1973]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (sibilants) MSC + alternations

Tashlhiyt, Agadir dial. (Berber; Morocco) [Lahrouchi 2003, 2005]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (sibilants) MSC + alternations

Tashlhiyt, Imdlawn dial. (Berber; Morocco) [Elmedlaoui 1995]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (sibilants) MSC + alternations (with blocking)

Teke-Gabon (Bantu; Gabon, Congo) [Greenberg 1951, Hyman 2006 based on Hombert 1993]
nasal consonant harmony MSC (+ alternations, historically?)

Tepehua, Tlachichilco (Totonacan; Veracruz) [Watters 1988]
coronal harmony (sibilants) MSC + alternations
dorsal harmony MSC + alternations

Thao (Austronesian; Taiwan) [Blust 1995]
coronal harmony (fricatives, incl. laterals) historical sound changes (sporadic)

Tiene (Bantu; D.R.C.) [Ellington 1977, Hyman & Inkelas 1997, Hyman 2006]
nasal consonant harmony MSC + alternations

Tlachichilco Tepehua; *see* Tepehua

Tonga (Bantu; Zambia, Zimbabwe) [Collins 1975]
nasal consonant harmony MSC + alternations

Totonac, Misantla (Totonacan; Veracruz) [MacKay 1999]
coronal harmony (sibilants) MSC + alternations
dorsal harmony MSC + alternations

Tsilhqot'in (Chilcotin) (Athapaskan; British Columbia) [Krauss 1975, Cook 1983, 1987, 1993, Andrews 1988, Gafos 1999, Hansson 2007c]
secondary-articulation harmony (sibilants) MSC + alternations

Tsuut'ina (Sarcee) (Athapaskan; Alberta) [Cook 1978, 1979, 1984]
coronal harmony (sibilants) MSC + alternations

Tuareg, various diall. (Berber; Niger, Mali, Algeria) [Alojaly 1980, Sudlow 2001, Heath 2005]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (sibilants) MSC + alternations

Tututni (Athapaskan; Oregon) [Golla 1976]
coronal harmony (sibilants) MSC + alternations

Tzeltal (Mayan; Chiapas) [Kaufman 1971]
coronal harmony (sibilants) MSC + alternations

Tzotzil (Mayan; Chiapas) [Weathers 1947, Cowan 1969, McCarthy 1989, MacEachern 1999]
coronal harmony (sibilants) MSC + alternations
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC

Tzutujil (Mayan; Guatemala) [Dayley 1985, McCarthy 1989, MacEachern 1999]
coronal harmony (sibilants) MSC
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC

Ulithian (Oceanic; Federated States of Micronesia) [Sohn & Bender 1973]
nasal consonant harmony alternations (limited)

Ventureño; *see* Chumash

Wanka Quechua; *see* Quechua

Wiyot (Algic; California) [Teeter 1959, 1964]
coronal harmony (sibilants) MSC + alternations
liquid harmony (lateral *vs.* rhotic) MSC + alternations

Yabem (Oceanic; Papua New Guinea)[Dempwolff 1939, Bradshaw 1979, Ross 1993, 1995, Hansson 2004b]
laryngeal harmony? (stops; epiphenomenal) MSC + alternations
stricture harmony (coronal obstruents) MSC + alternations
nasal consonant harmony? alternations (featural affixation)

Yucatec, Classical (Mayan; Yucatán) [McQuown 1967, Lombardi 1990, Noguchi 2007]
coronal harmony (sibilants) MSC
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC

Yucatec, Modern (Mayan; Yucatán) [Straight 1976, Lombardi 1990, Noguchi 2007]
coronal harmony (sibilants) MSC
laryngeal harmony (plosives) MSC
major-place harmony? (ejectives) MSC
stricture harmony (affricates *vs.* fricatives, stops) MSC

Zayse (Omotic; Ethiopia) [Hayward 1988, 1990b]
coronal harmony (sibilants) MSC + alternations

Zoque (Mixe-Zoquean; Tabasco) [Wonderly 1951]
secondary-articulation harmony? alternations

Zulu (Bantu; South Africa, Lesotho, Swaziland, Malawi) [Khumalo 1987, Hansson 2004a]
laryngeal harmony (stops) MSC

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