True Output Theory:
The Phonetics and Phonology of Low Vowel Lengthening in Hungarian*

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1 Introduction

What the distinction is between phonology and phonetics has always been a central question for many linguists. A common answer, or partial answer, at least since SPE, is that phonology is concerned with the patterning of speech sounds according to discrete and contrastive categories, while phonetics is concerned with gradient and non-contrastive detail. There has been a recent rekindling of interest in the phonetics-phonology interface, and much is currently being written on the topic. The analysis presented in this paper includes an introduction to what I call True Output Theory (TOT), a theory which incorporates phonetics into the phonology. Yet, I take a more conservative approach than many by restricting the interaction to the particular instance of output-output constraints.

TOT is also an answer to the question of *what should be considered the base* for OO constraints. The answer is that the base is actually the form that is produced. This form, what I call the "true output", clearly differs from what has previously been considered the "output", what I will now call "the phonological output". In most cases, the true output will not differ noticeably from the phonological output, except that it must be represented in richer detail, the very detail that is often omitted from phonological representations because they are non-contrastive. These details may include aspiration, devoicing, nasalization, length, or any range of phonetic detail in the language.

In this paper I investigate the phonetic effect of word-final lengthening on the phonology, as an explanation for a vowel length alternation in Hungarian called Low Vowel Lengthening (LVL). Previous accounts of LVL have been exclusively rule-based, and, while mostly descriptively adequate, have made no significant headway into explaining *why* LVL should occur in Hungarian, nor have they connected this phenomenon to other vowel-related phenomena in the language.

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The analysis I present below explains LVL by drawing connections to more general restrictions on vowel length in word-final position and by implementing output-output constraints in an Optimality Theoretic (OT) framework (Prince and Smolensky 1993/2004). I conclude that speakers of Hungarian generalize from phonetic length to phonological length, and that the other vowel features fall out predictably.

In the first section I present the facts of LVL and provide relevant general background in Hungarian. In the second section, I present previous accounts of LVL and show why they are unsatisfactory. In section 3, I present evidence from the other Hungarian vowels, from Hungarian pronunciation of foreign words and from word-final lengthening. In section 4, I present the analysis, beginning with an account of TOT in 4.1. In 4.2, I present tableaux and give a constraint ranking. In section 5, I turn to phonetic support for my claims first from an experiment and then from a database of Hungarian words. In section 6, I account for apparent exceptions and conclude the paper in section 7.

2 Low Vowel Lengthening and Background

2.1 Low Vowel Lengthening

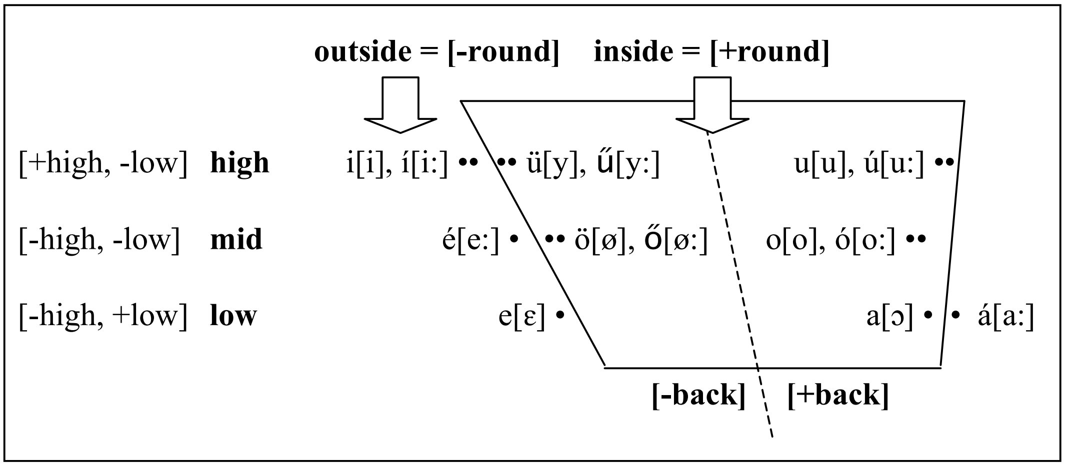
There is a vowel length alternation in Hungarian, typically termed "Low Vowel Lengthening" (LVL), which, descriptively, consists of a short, low vowel lengthening before a suffix. Because Hungarian is an agglutinative language, and LVL is fully productive, it occurs frequently in the language. The examples in (1) show LVL occurring for both low vowels: [ɔ] and [ɛ]. Notice that LVL can occur as many times in a word as there are environments. The relevant vowels are underlined.

(1) Low Vowel Lengthening
ɔlmɔ ('apple') → ɔlma:t ('apple acc.')
e:rmɛ ('coin') → e:rme:k ('coins')
pa:rnɔ ('pillow') → pa:rna:jɔ ('his pillow') → pa:rna:ja:t ('his pillow', acc.)
tʃirkɛ ('chicken') → tʃirke:jɛ ('his chicken') → tʃirke:je:t ('his chicken', acc.)

2.2 Background

Hungarian (Finno-Ugric) has fourteen vowels, which form seven short-long pairs. These are distributed as indicated in (2). For every vowel, the orthography is provided on the left and the IPA symbol is in square brackets on the right. The dots indicate rough locations of the vowels, but this is clearly a simplification. For more detail, see Siptár and Törkenczy (2000).

(2) Hungarian vowel inventory



Vowels in Hungarian are distinguished by a number of features: [±back], [±round], [±high], [±low], and by length. All of these features are phonemic. In (3), I demonstrate the phonemic status of vowel length. The examples are taken directly from Kenesei, at al., 1998.

(3) Vowel length is phonemic

Short			Long		
/i/	irt	'exterminate'	/i:/	ír-t	'write-PAST'
/y/	üröm	'wormwood'	/y:/	űr-öm	'vacuum-POSS.1SG'
/u/	szurok	'tar'	/u:/	szúr-ok	'stab-INDEF.1SG'
/ɛ/	vesz	'take'	/e:/	vész	'plague'
/ø/	tör	'break'	/ø:/	tőr	'dagger'
/o/	kor	'age'	/o:/	kór	'disease'
/ɔ/	hat	'six'	/a:/	hát	'back'

The quality differences for the two pairs of low vowels [ɛ] and [e:] and [ɔ] and [a:] are significant, but do not detract from their status as short-long pairs. These vowels pattern together, both orthographically (as can be seen in (2)) and phonologically. Although [e:] is actually articulated as a mid vowel, it is traditionally treated as a low vowel. Additionally, it forms a group with the other three low vowels and contrasts with the mid and high vowel pairs in a number of ways.

The first way in which these vowels differ from the mid and high vowels is that there is a quality difference as well as a length contrast between only the low vowel pairs.While [ɔ] and [a:] are both low vowels, [ɔ] is slightly less low and is [+round], while [a:] is [-round]. While [ɛ] is also low, its long counterpart is actually mid. The other five vowel pairs do not contrast significantly in more than length.

Second, only the low vowels are not affected by the prohibition against a V:CC sequence in Hungarian roots (Siptár, Törkenczy 2000). That is, there are words such as [e:rc][1] 'ore' and

1. The examples given are from Siptár and Törkenczy, 2000. For more details, see page 150.

[ma:rt] 'dip', both monosyllabic, as well as a V:CC sequence across a syllable boundary, such as [e:rte:k] 'value' and [a:rpɔ] 'barley', but there are no words in which the vowel of the sequence is not [a:] or [e:]. Thus the language has the word [si:r] 'grave', but no word [si:rt][2].

Moreover, only [ɔ] and [ɛ] are selected by certain lexically specified "lowering stems" (Siptár, Törkenczy 2000). These stems require a low vowel before a C-initial suffix, even when that vowel is not the most harmonic choice, as in (b) and (c). The choice between [ɔ] and [ɛ] is determined by vowel harmony. The last two columns of table in (4), show how the low vowel differs from the stem vowel in terms of height and rounding.

(4) Lowering Stems

	Attested Form	Unattested Forms	Height	Rounding
a.	ha:z → ha:zɔt		same	different
b.	fyl → fylɛs	*fylys, *fylis, *fylys	different	different
c.	hi:d → hi:dɔt	*hi:dit, *hi:dyt	different	different
d.	ke:z → kɛzɛt		same[3]	same

The vowel is not a regular epenthetic vowel, because it occurs even when a complex coda would be allowed. The following minimal pair exemplifies this:

(5) [ház] becomes [házat] in the accusative, but [gáz] becomes [gázt].

Finally, only the low vowels alternate in length stem-finally. This last phenomenon is LVL. There are many suffixes in Hungarian which trigger lengthening. Examples are provided in (6) and (7), but for simplicity, I will use only the accusative marker [-t] for the remainder of my examples.

(6) Examples of [ɔ] → [a:]

Suffix		Unsuffixed			Suffixed		
-bɔn	inessive	iskola	[iʃkolɔ]	school	iskolában	[iʃkola:bɔn]	in school
-bb	'more _'	mafla	[mɔflɔ]	stupid	maflább	[mɔfla:bb]	stupider
-jɔ	3rd p. sg.	pipa	[pipɔ]	pipe	pipája	[pipa:jɔ]	his pipe
-ig	'as far as..'	fa	[fɔ]	tree	fáig	[fa:ig]	as far as a tree
-k	plural	gólya	[go:jɔ]	stork	gólyák	[go:ja:k]	storks
-m	1st p. sg.	apa	[ɔpɔ]	father	apám	[ɔpa:m]	my father
-n	'on'	bálna	[ba:lnɔ]	whale	bálnán	[ba:lna:n]	on whale
-n	adverb	lusta	[luStɔ]	lazy	lustán	[luʃta:n]	lazily
-nɔk	dative	marha	[mɔrhɔ]	cattle	marhának	[mɔrha:nɔk]	cattle (dat.)
-rɔ	'to, until'	Prága	[pra:gɔ]	Prague	Prágára	[pra:ga:rɔ]	to Prague
-ro:l	delative	Buda	[budɔ]	Buda	Budáról	[buda:ro:l]	from Buda

2. Note that these words are mono-morphemic. V:CC sequences are allowed with other vowels in multi-morphemic words.
3. For independent reasons the stem vowel shortens here.

-ʃ	adjective	kocka	[kotskɔ]	square	kockás	[kotska:ʃ]	checkered
-t	accusative	málna	[ma:lnɔ]	raspberry	málnát	[ma:lna:t]	raspberry, acc
-ul	'like'	macska	[mɔtʃkɔ]	cat	macskául	[mɔtʃka:ul]	like a cat

(7) Examples of [ɛ] → [e:]

Suffix		Unsuffixed			Suffixed		
-bɛn	inessive	ige	[igɛ]	word	igében	[ige:bɛn]	in the word
-bb	more _	enyhe	[ɛ˜hɛ]	mild	enyhébb	[ɛ˜he:bb]	milder
-jɔ	3rd p. sg.	teve	[tɛvɛ]	camel	tevéja	[tɛve:jɔ]	his camel
-ig	'as far as..'	kefe	[kɛfɛ]	brush	keféig	[kɛfe:ig]	as far as the brush
-k	pl.	remete	[rɛmetɛ]	hermit	remeték	[rɛmɛte:k]	hermits
-m	1st p. sg.	rege	[rɛgɛ]	legend	regém	[rɛge:m]	my legend
-n	'on'	képe	[ke:pɛ]	his picture	képében	[ke:pe:bɛn]	on his picture
-n	adverb	renyhe	[rɛ˜hɛ]	inert	renyhén	[rɛ˜he:n]	inactively
-nɛk	dative	érme	[e:rmɛ]	coin	érmének	[e:rme:nek]	coins, dat.
-rɔ	'to,until'	este	[ɛstɛ]	evening	estére	[ɛste:rɛ]	until evening
-ro:l	delative	körte	[kørtɛ]	pear	körtéről	[kørte:ro:l]	from the pear
-ʃ	adj.	béke	[be:kɛ]	peace	békés	[be:ke:ʃ]	peaceful
-t	acc.	teke	[tɛkɛ]	ball	tekét	[tɛke:t]	ball, acc.
-ul	'like'	csirke	[tʃirkɛ]	chicken	csirkéül	[tʃirke:yl]	like a chicken

Since there is evidence that these vowels should be treated as two short-long pairs, we can account for them with the constraints in (8) through (11).

(8) A = [ɔ] A short, low, back vowel must be rounded.
(9) A: = [a:] A long, low, back vowel must be unrounded.
(10) E = [ɛ] A short, non-high, unrounded, front vowel must be phonetically low.
(11) E: = [e:] A long, non-high, unrounded, front vowel must be phonetically mid.

This is simply a shorthand representation of the fact that in the main Budapest variety of Hungarian low back vowels which are both short and [-round] are prohibited, as are low back vowels which are long and [+round]. Clearly, these constraints are a part of the grammar, and could be formalized in any number of ways. I choose the formulations in (8) through (11) for their transparency.

3 Previous Accounts

There have been a number of linguists who have noticed and analyzed LVL (Vago 1978, Magnus 1992, Törkenczy 1997, Kenesei at al. 1998, Nádasdy and Siptár 1998, Siptár and Törkenczy 2000, Rounds 2001, among others), but none of these approaches has been fully satisfactory. Previsous analyses can be divided into vowel shortening and lengthening analyses. I take them both up below.

3.1 Vowel Shortening

According to a vowel-shortening analysis, vowels are long in their underlying form when suffixed and shorten word-finally. The final vowel of [ɔlmɔ] is thus actually underlyingly long (/ɔlma:/), but shortens word finally. A typical rule would look like that in (12). Derivations are given in (13).

(12) $V_{[+low, +long]} \rightarrow V_{[-long]}$ / _ $]_{wd}$
A long, low vowel shortens before a word boundary.

(13) Derivation of *alma* | Derivation of *almát*

input:	/almá/	input:	/almá-t/
V-shortening:	alma	V-shortening:	----
output:	[alma]	output:	[almát]

The vowel-shortening rule accounts for most, but not all, of the data. There are words in Hungarian that end in long, low vowels. Word-final [a:] and [e:] are limited to function words, affixes, loanwords, acronyms, interjections and names of letters (Siptár and Törkenczy 2000, Kenesei et al. 1998), but they do need to be accounted for. Many of the loanwords, for example, are now quite nativized, such as the word for coffee, *kávé*. In (10) some examples are provided of words that end in long, low vowels.

(14) Words that end in long, low vowels

word-final *á*		word-final *é*	
a. burzsoá	'bourgeois' (loan)	h. kabaré	'cabaret' (loan)
b. hajrá	'a rush/final spurt' (native)	i. izé	'whatcha-ma-callit' (native)
c. zéhá	'written examination' (acronym)	j. kordé	'cart' (native)
d. géemká	'entertainment cooperative' (acronym)	k. püré	'puree' (loan)
e. fa	of the do-re-mi sequence (name of note)	l. büfé	'buffet' (loan)
f. hurrá	'hooray' (interjection)	m. lé	'liquid' (native)
g. ad-ná	'give-CON.DEF.3SG' (suffix)	n. grof-né	'countess by marriage' (suffix)

The problem presented by these words is difficult to resolve with rules. One possibility would be to restrict the rule to a special class of words. Additionally, in an Optimality Theoretic framework, we could consider some kind of IDENT constraint. Neither of these options is viable, however, because the words in question do not form a natural class. An IDENT-FOREIGN constraint would not protect the length of final vowels in suffixes or function words, for example.

Moreover, even if we could formulate an IDENT-EVERYTHING-EXCEPT-MOST-NATIVE-STEMS, we would need to restrict it to protect only long vowels, but not the short vowels. If it applied to all vowels we would have problems for loanwords (and affixes, etc.) that end in *short*, low vowels, as in (15).

(15) Foreign words which end in short, low vowels

diploma	'diploma'	*szonáta*	'sonata'
maffia	'mafia'	*pilóta*	'pilot'
kategória	'category'	*dogma*	'dogma'
propaganda	'propaganda'	*oboa*	'oboe'

If these words were 'protected' by IDENT-FOREIGN-ETC. then how would the final vowel be long before a suffix, as in (16)?

(16) *diploma* 'diploma' but *diplomát szerez* 'receive a diploma (acc.)

Clearly, the shortening analysis falls short. The restrictions on the rule or the form of the constraint would have to be highly stipulative and unnatural. Moreover, it would necessarily rely on a restricted distribution of vowels word-finally, which, given Richness of the Base **(**Prince and Smolensky 1993/2004), is an undesirable claim to make.

3.2 Vowel Lengthening

Turning now to the vowel lengthening approach, we see that it is more successful. Under this analysis, vowels that appear short word-finally are underlyingly short, but lengthen when followed by a suffix. A rule that illustrates this analysis appears in (17) and derivations in (18).

(17) $V_{[+low, -long]} \rightarrow V_{[+long]}$ / _ $]_{morph}$ X, where X is non-null.
A short, low vowel lengthens before a morpheme boundary, which is not also a word boundary.

(18)

Derivation of *alma* [ɔlmɔ]		Derivation of *almát* [ɔlma:t]	
input:	/ɔlmɔ/	input:	/ɔlmɔ-t/
V-lengthening:	---	V-lengthening:	ɔlma:t
output:	[ɔlmɔ]	output:	[ɔlma:t]

The importance of the caveat "where X is non-null" can be seen in the derivation of /ɔlmɔ/. Because the morpheme boundary is also a word boundary, no lengthening occurs.

Unlike the vowel shortening analysis, this approach can account for all of the data, as words like *kávé* ('coffee') and *diploma* are both successfully derived, and there is no need for highly stipulative caveats and restrictions on the rule. However, while superior to vowel shortening, the vowel lengthening analysis still does little more than describe the facts.

The analysis I provide below accounts for the distribution of low vowels word-finally and is superior to earlier accounts in that it does not rely on a restricted distribution of vowels word-finally (allows for Richness of the Base), explains why LVL occurs by drawing on general facts about the language for support, and is cast in an OT framework.

4 Three Pieces of Evidence

4.1 Evidence From the Other Vowels

Before turning to the constraints themselves, let us look for a moment at the other vowels in Hungarian. There is a restricted distribution of all vowels word-finally. The high vowels, similar to the low vowels, are restricted to short vowels word-finally, while the mid vowels, surprisingly, have the opposite restriction: only the long member of the short-long pair can occur word-finally.

(19) Distribution of vowels word-finally

high	i	
	i:	prohibited
	y	
	y:	tends to be short even when spelled long
	u	
	u:	tends to be short even when spelled long
mid	ø	prohibited
	ø:	
	o	prohibited
	o:	
low	ɛ	
	e:	mostly non-major lexical categories and loans
	ɔ	
	a:	mostly non-major lexical categories and loans

Historically (9th-13th centuries), there seems to have been a restriction in Hungarian requiring all word-final vowels to be short (Kálmán 1972, reported in Myers, to appear). This seems to still generally hold for the high and the low vowels. While the mid vowels have a mysterious opposite restriction, it should be noted that it is nevertheless still predictable which member of the pair will occur word-finally.

Ignoring the mid vowels for now, I hypothesize that the restriction to be short word-finally was historically very strong, but that it has weakened over time, possibly because of an influx of loanwords. I suggest that a once undominated constraint requiring this, as in (20), is still present in the language but is now lower ranked. Its past highly ranked status can account for the present rarity of words that violate this constraint.

(20) *LONGV]WD
Long vowels are prohibited at the left edge of a prosodic word[4].

4. I am ignoring here the mid vowels, which must be long word-finally. This could be solved in a number of ways, such as restricting this constraint to only low (and high) vowels or by having a more highly ranked constraint that prohibits short mid vowels. I suggest for now the latter approach on the grounds that I can then continue to ignore the mid vowels for the remainder of this paper without having to complicate the relevant constraint. Certainly this issue should be pursued further.

The question of whether this constraint is still a part of the grammar or not is a good one. It could be claimed that since the constraint no longer holds (e.g. kávé), it no longer exists, and instead word-final vowels are lexically specified long or short. I have two reasons to disagree. First, if constraints are truly universal, then so must this one be. Many languages with phonemic vowel length require their vowels to be short word-finally. As a universal constraint, it is in every grammar, just lowly ranked in most, such that it is undetectable. In Hungarian, then, it is no longer as highly ranked as previously, but has been demoted through time. It is still present in the grammar, just no longer undominated.

My second reason for suggesting that we consider this constraint, is that it captures the majority of the Hungarian data, including an (almost) exceptionless[5] restriction on word-final long [i:]. It is far simpler to assume that this constraint is still at work, but that the exceptions are somehow allowed because of the existence and relative ranking of other constraints, which I shall not go into here. Additionally, for the majority of word-final vowels, we do not have to specify the length. Only for the words with word-final long vowels must we specify that they are long. This is one way in which this analysis is simpler than the lengthening or shortening approaches: the grammar does most of the work.

Since it is clear that the final vowel in words like *kávé* must be specified for length, I suggest we turn to a MAX-μ constraint. Ranked over *LONGV]WD, this ensures that the final vowel in *kávé* will be long in the output, as in (21). A form like *alma* ('apple') is also correctly predicted by this ranking, as in (22).

(21) tableau 1 'coffee, nom.' MAX-μ >> *LONGV]WD

	/ka:ve:/	MAX-μ	*LONGV]WD
a.	☞ [ka:ve:]		*
b.	[ka:ve]	*!	

(22) tableau 2 'apple, nom.'

	/ɔlmɔ/	MAX-μ	*LONGV]WD
a.	[ɔlmɔ:]		*!
b.	☞ [ɔlmɔ]		

We can assume that DEP-μ constraint would also have been violated by candidate (a) in tableau 2, but we cannot determine its ranking above or below *LONGV]WD. For this reason I leave DEP-μ out of the tableaux.

4.2 Evidence from Hungarian Pronunciation of Foreign Words

Farkas (1997 and p.c.) observed that Hungarian speakers will preserve quantity (length) before quality in pronouncing foreign Romanian, French and English words. When pronouncing foreign vowels, length faithfulness is ranked over backness, height, rounding, etc.

5. Long [i:] occurs word-finally only in a few monosyllabic words. In can be assumed that this length is due to a minimal word effect (Kenesei et al, 1998). One example is *sí* (Si:) *'ski'*.

Farkas showed this by asking native speakers of Hungarian to pronounce Romanian words. Some sample results are presented in (23). The Hungarian pronunciation of the word for "cow" preserves the length of the first syllable, which is presumably long because it is stressed, as indicated by the accent mark, but changes the quality of the second vowel to preserve its short duration. The same occurs for the first vowel in example (2). Again, the vowel is rounded so that it may be pronounced short. A change in quality to preserve length is also demonstrated for the front low vowel in (2-4), and we can see that the high, front vowel is also lengthened in example (2).

(23) Examples of Hungarian pronunciation of Romanian (Farkas 1979)

		Romanian		Hungarian	
1.	R [a:] → H [a:]	Váca	→	va:kɔ	'cow'
2.	R [a] → H [ɔ]	parízer	→	pɔri:zɛr	'kind of sausage'
3.	R [e:] → H [e:]	Bleg	→	ble:g	'blockhead'
4.	R [e] → H [ɛ]	buletin	→	bulɛtin	'ID'

These data suggest that the Hungarian ear is somehow *attuned* to length as a key identifying feature. This is unsurprising, considering that length is phonemic for both consonants and vowels in the language. Yet, this shows that it is not only as important, but rather *more* important than either roundness or height.

4.3 Evidence from Word-Final Lengthening

Myers (to appear) and Myers and Hansen (to appear) argue that for languages with phonemic vowel length, this contrast is often lost word-finally due to a difficulty in detection because of word-final lengthening. Length neutralization leads speakers to make a phonological generalization about the restriction of vowels in this position, choosing either long or short vowels to restrict.

There is evidence of final vowel lengthening in Hungarian (Hockey and Fagyal 1999), and Kassai (1979, 1982, reported in Hockey and Fagyal and elsewhere) shows that vowels and consonants both are longer at the ends of words. There does seem to have been a neutralization of vowel length in this position. Hungarian speakers seem to have chosen a combination restriction, apparently requiring low and high vowels to be short and mid vowels to be long, although this current phonotactic distribution is likely a combination of a number of independent factors. It is possible that the restriction to short vowels developed in the same way as in Finnish. Myers shows further that in Finnish partial final vowel devoicing has lead speakers to perceive these vowels as short. From this they have generalized that all vowels word-finally must be short. This is a case of perceived (phonetic) shortening leading to a generalized phonological restriction.

Because word-final lengthening is also phonetic, it can exist in a language simultaneously alongside a phonological word-final restriction to short vowels. I predict that word-final lengthening in Hungarian yields a phonetically-long, phonologically short vowel, such as [ɔlmɔ:]. Just as speakers of Finnish latched on to the perceived shortness of their devoiced vowels, I suggest Hungarian speakers latched on to the perceived length of their vowels, and generalized from this.

5 The Analysis

5.1 From TCT to TOT

Benua's (1997) Transderivational Correspondence Theory (TCT) provides exactly the right machinery to account for LVL. Output-Output constraints are able to account for "cyclic effects" in a non-derivational optimality theoretic way. The output form of the base word (e.g. *alma*) influences derived forms (e.g. *almát, almának, almás,* etc.) through an OO-Identity constraint, in this case OO-Ident[Length].

(24) OO-Ident[Length] (OO-Length)
A morphologically derived surface form stands in correspondence with its base form for length. One violation is incurred for every segment in the derived form which differs in length from the base form.

TCT is inherently asymmetric because Base Priority keeps derived forms such as *almát* from influencing the morphologically simplex base *alma*. This explains why we see phonological lengthening, complete with rounding or height feature changes, before suffixes, but not in unsuffixed base forms. That is, this theory correctly predicts that the optimal candidate for the input /ɔlmɔ/ will be [ɔlmɔ], not [ɔlmaː].

Naturally, there must be other OO-Identity constraints particular to other features such as [round] and [low]. These constraints will be crucially ranked below OO-Length, because [length] proves to be the main defining feature for Hungarian vowels. I'll return to this point later.

To use Benua's schematic representation (Benua 1997), Low Vowel Lengthening is a result of the relationships shown in (25).

(25) schematic representation

		OO-Length		
	[ɔlmɔː$_i$]	→	[ɔlmɔː$_i$ + t]	
IO-Faith + WFL	↑		↑	IO-Faith
	/ɔlmɔ/		/ɔlmɔ + t/	

The representation in (25) differs from Benua's in that I've added word-final lengthening to the Input-Output constraints. This is not quite right, as WFL is a phonetic rather than phonological process, but it raises the issue of how to determine the base string. In this paper I will sidestep the issue of whether or not that string must be morphologically well-formed. Since the base is morphologically well-formed, I will follow Benua and others in assuming it must be so, but this is a decision motivated by convenience rather than an argument.

My concern with regard to determining the base string is what gets considered an output. Should phonetic factors, such as word-final lengthening, which clearly affect the final pronunciation of a word, be considered in determining a base string? That is, the output of /ɔlmɔ/, in a traditional tableau, will be [ɔlmɔ]. This, according to traditional ideas is the base used for OO-Ident constraints. I argue, however, that this is not, in fact, the base. Instead, the base is the "true output", which is the form that is actually *produced*[6], the phonetic output. A form like [ɔlmɔ] may be the phonological output, possibly what we think in our heads to be the correct form, but it is the *phonetic* form, what we actually say, that is the base for OO constraints. The revised schema is given in (26).

(26) Revised schematic representation

	Phono-logical output	Phonetic Effects (WFL)	True output (= phonetic output)	OO-Ident (Length)	Phono-logical output	
	[ɔlmɔ]	→	"[ɔlmɔ:]"	→	[ɔlma:t]	
Phono-logical constraints	↑				↑	Phono-logical constraints
Input	/ɔlmɔ/				/ɔlmɔ + t/	Input

The input /ɔlmɔ/ leads to the phonologically determined output, what is traditionally termed the output, [ɔlmɔ]. This form, however, when actually produced, is subject to phonetic effects, in this case word-final lengthening. This yields the "true output", "[ɔlmɔ:]". I've used the quotation marks around the brackets as a shorthand to indicate that this is the phonetic form actually produced. This form is then the base for the OO-LENGTH constraint. The OO constraints are actually a part of the phonology with the other IO constraints that, combined, yield a new phonological output for the derived form, [ɔlma:t]. Although I have left it out of the diagram in (26), this phonological output, like all others, is potentially affected by phonetic effects, yielding a true output. True outputs may differ from phonological outputs or they may not. In cases where the phonology produces forms which undergo no specific change, there will be no difference between the phonological and the true outputs.

This, I'm sure, will be a very controversial move. It appears that I am expanding the machinery, which is always cause for careful scrutiny. I suggest, however, that I am not creating any new machinery. I am instead redefining the notion of the "base" by incorporating familiar phonetic phenomena into the overall portrait of phonology. If anything is truly "new", it is only the notational device I employ above, which itself is certainly in need of refinement.

It has always been accepted that phonetic processes occur. Besides word-final lengthening we could consider any number of other effects, such as the precise allophone of /t/. Yet, for English, such phonetic detail is omitted from the transcription of the (phonological) output. Because these details have not been seen to be significant, there has been no need to include them in our OT tableaux. Yet, we must then concede that our "outputs" do not exactly represent what is produced.

6. It may be more accurate to say that the output is what is perceived to have been said, as may be the case with Finnish partial final devoicing (Myers, to appear). For this analysis there seems to be no significant discrepancy between what is perceived to have been said and what is said, so this issue will remain unresolved for now.

If, however, we discover that these phonetic details do effect the phonology (by OO constraints or paradigm uniformity), it then becomes necessary to incorporate them into our understanding of phonology, and into our current framework: OT. This is precisely what Steriade (2000) has found.

Steriade (2000) demonstrates that noncontrastive phonetic properties are in fact crucial to our understanding of paradigm uniformity and that they play a role in the phonology just like contrastive phonological features. She further suggests that the distinction between phonological features and phonetic details is perhaps not so great as we have presumed. Moreover, she claims that the feature sets of phonology and phonetics should not be distinct, or at least the distinction should not be drawn by contrastivity.

In these points, I follow Steriade. Just as she found phonetic properties (i.e. [extra short closure]) to play a role in the occurrence of flapping and absence of flapping in *capitalistic* and *militaristic*, respectively, I demonstrate now that phonetic length affects the phonological length pattern of low vowels before suffixes.

5.2 The Machinery

In previous sections, I motivated the constraints in (20) and (24), repeated as (27) and (28) below. Recall, also, that *LongV]wd is crucially ranked over MAX-μ.

(27) *LongV]wd
Long vowels are prohibited word-finally.

(28) OO-Ident[Length] (OO-Length)
A morphologically derived surface form stands in correspondence with its base form for length.

Recall also the constraints presented in section 1, repeated below.

(29) A = [ɔ] A short, low, back vowel must be rounded.
(30) A: = [a:] A long, low, back vowel must be unrounded.
(31) E = [ɛ] A short, non-high, unround, front vowel must be phonetically low.
(32) E: = [e:] A long, non-high, unround front vowel must be phonetically mid.

Now, to return to the familiar forms *alma, almát, kávé* and *kávét*, the correct constraint ranking is determined below.

(33) Tableau 3 'apple, nom.'

/ɔlmɔ/	A = [ɔ]	A: = [a:]	*LONGV]WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. ɔlma	*!					
b. ɔlma:			*!			
c. ☞ ɔlmɔ						
d. ɔlmɔ:		*!	*			
c′. 💬 ɔlmɔ:	word-final lengthening: "[ɔlmɔ:]"					

(34) Tableau 4 ‘apple acc.’ OO[length] >> OO[round], OO[height]

/ɔlmɔ + t/ [ɔlmɔ:]	A = [ɔ]	A: = [a:]	*LONGV]WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. ɔlmat	*!			*	*	
b. ☞ ɔlma:t					*	
c. ɔlmɔt				*!		
d. ɔlmɔ:t		*!				
b′ 💬 ɔlma:t	“[ɔlma:t]”					

(35) Tableau 6 ‘coffee, nom.’ MAX-μ >> *LONGV]WD

/ka:ve:/	E = [ɛ]	E: = [e:]	MAX -μ	*LONGV] WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. ka:ve	*!		*				
b. ☞ ka:ve:				*			
c. ka:vɛ			*!				
d. ka:vɛ:		*!		*			
b′ 💬 ka:ve:	“[ka:ve:]”						

(36) Tableau 5 ‘coffee, acc.’

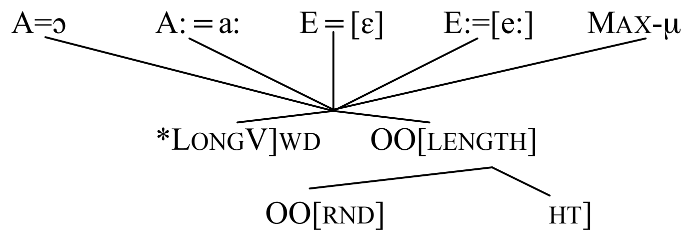
/ka:ve: + t/ [ka:ve:]	E = [ɛ]	E: = [e:]	MAX -μ	*LONGV]WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. ka:vet	*!		*		*		
b. ☞ ka:ve:t							
c. ka:vɛt			*!		*		*
d. ka:vɛ:t		*!					*
b′. 💬 ka:ve:t	“[ka:ve:t]”						

These constraints, which are universal, with this Hungarian-specific ranking, capture the intuition that length is the key difference between *a* and *á* and between *e* and *é*. This is unsurprising because it was already noted that these vowels form two short-long pairs.

Length, then, is the defining featural difference, and the other features (height and roundness) come along as predictable side-effects (e.g. if a low, back vowel is long, it must also be [-rnd]), because of the particular ranking established above. The final total ranking is given below.

(37) Total ranking

A=[ɔ], A:=[a:], E=[ɛ], E:=[e:], MAX-μ >> *LONGV]WD, OO[LNG] >> OO[RND],OO[HT]



6 Phonetic Support

6.1 Support From a Phonetic Experiment

To test True Output Theory, I devised a simple experiment. I prepared a list of 80 trisyllabic words. These words contained instances of each of the 14 vowels in each of two positions: in the medial syllable between a voiced stop and in the final syllalble and after a voiced stop in an open syllable. Thus the words were structured as in (38)(a) or (b)[7]. Some words satisfied both environmental criteria, and were doubly testable. The vowel in the first syllable was not measured. This was to avoid complication of stress, because Hungarian stress always falls on the first syllable.

(38) (a) CV(C)B_BV (b) CV(C)CVB_

Because it was difficult to find examples for every vowel/environment combination to fit into the templates in (38), a few words were invented by modifying real Hungarian words. In a post-experiment survey, participants indicated that 14 of the 80 words were "unknown" or "strange", but that all of these seemed like native Hungarian words and were fully pronounceable.

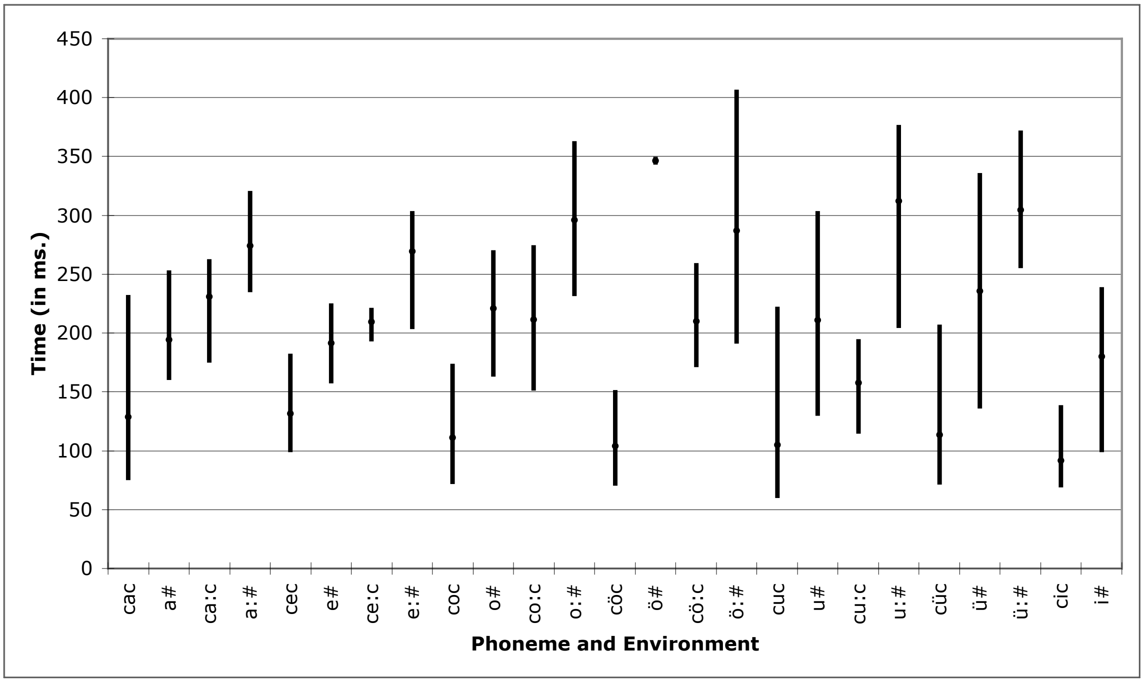
The 80 words were then randomized and divided into ten sub-lists. Extra words were added to the bottom of each list, so that these could be discarded. In this way, the target words were not list-final and should therefore have had a more uniform pronunciation. The words were also randomized differently for each reading, assuring that if there were any complications from the order of the list, this should be neutralized over the experiment.

Speakers were instructed to read the lists at a normal speech rate, but to pronounce them naturally. After three repetitions of this, a final sequence was recorded in which the speaker was asked to pronounce the words at a much faster rate, but to ensure that the words were still fully pronounced.

Using Praat (1992), I have measured the duration of the vowels in both positions. The results are presented in table (39).

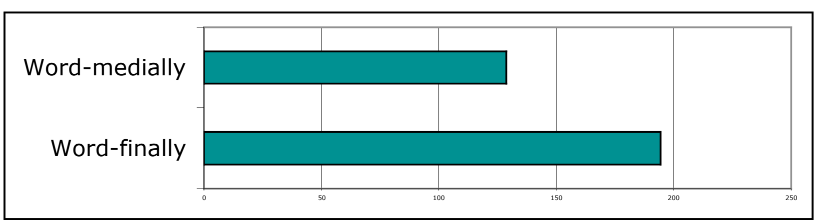
7. Here and throughout, "C" indicates any consonant"; "V", any vowel, long or short; "B" a voiced stop (b, d, g); and "_" the location of the target vowel.

(39) Vowel Duration- High, Low, Mean



In (39), the points indicates the mean lengths for each vowel in the environment shown. The vertical bar shows the range from shortest recorded duration (low) to longest (high). Analyzed by pairs, it is clear that word-final lengthening is, indeed, a significant characteristic of Hungarian. For example, word-medial [ɔ], marked as "cac" in the chart, has an average duration of 128.7 milliseconds. This same vowel, when word-final, has an average duration of 194.4 milliseconds. This is more than half again as long as word-medially and an almost 66 millisecond increase.

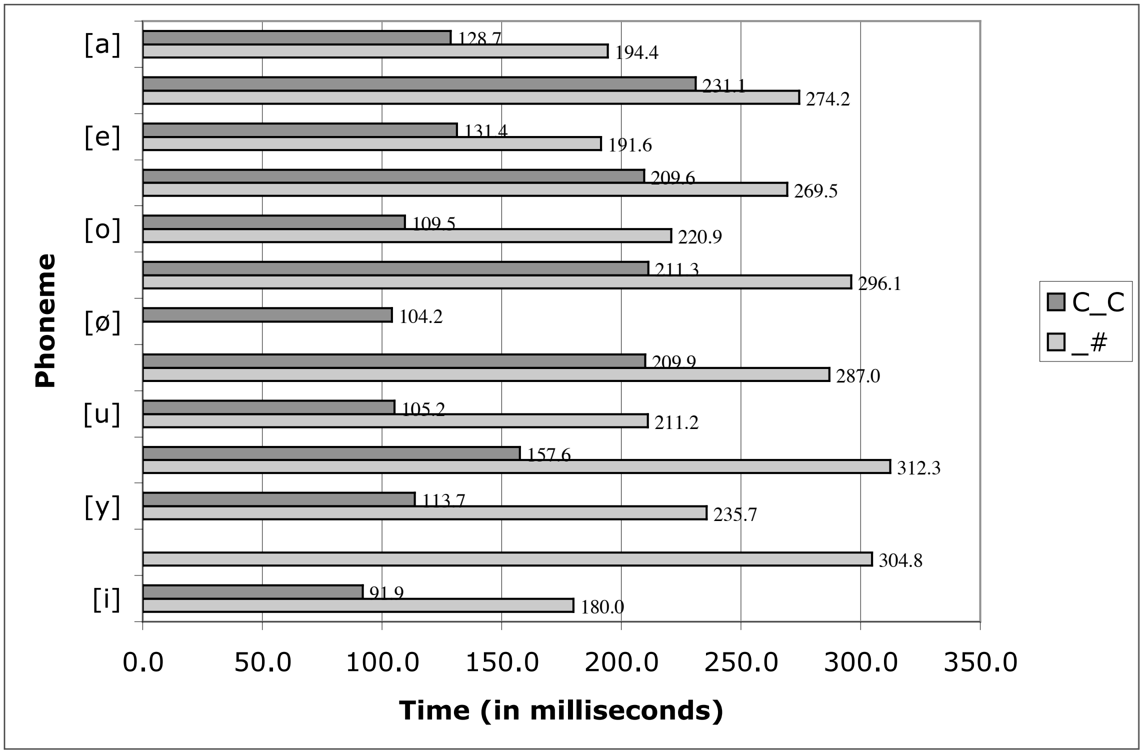
(40) Average Length of [ɔ] by environment



Besides word-final lengthening, the data also show that the word-final short vowel is always closer in duration to the word-medial long vowel than it is to its own word-medial average length. That is, phonologically short but phonetically long vowels are closer to phonologically long vowels than they are to phonologically and phonetically short vowels. For example, looking again at (39), word-final [ɔ], marked as "a#" in the chart, has a duration range almost identical to the range of word-medial [a:], marked as "ca:c". The same observation is true of the other low-vowel pair.

(41) provides an additional look at the duration averages. "C_C" indicates that a sound is word-medial.

(41) Vowel Duration Averages by Environment



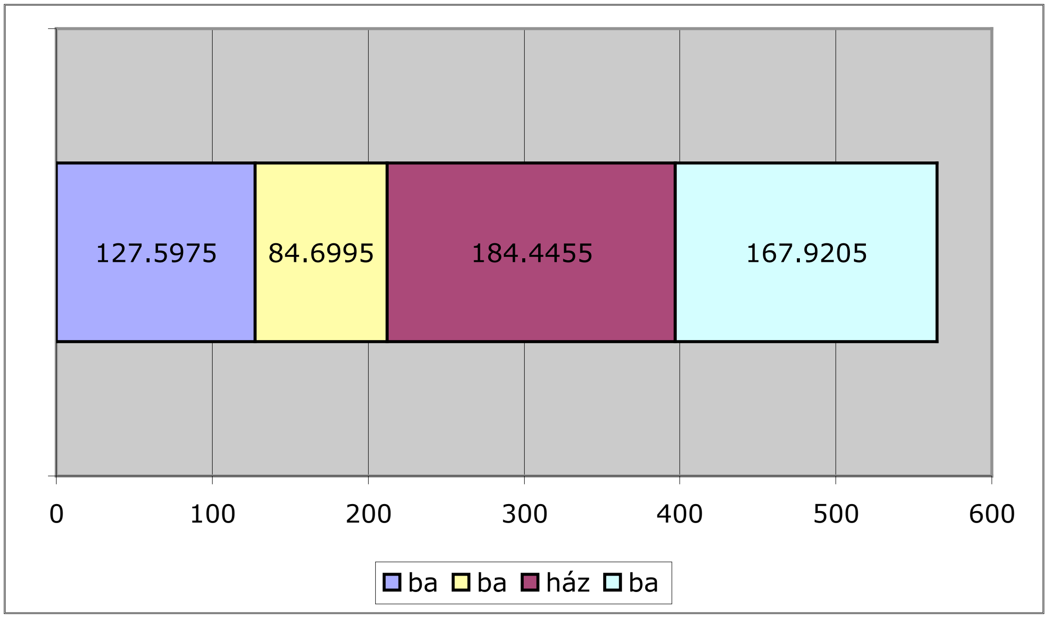
Recall that short mid vowels are said to be prohibited word-finally. I could find no native Hungarian word spelled with a final [ø], so it seemed unnatural to invent one for this study. That is why that category is not included. There are, however, words that end in a short [o]. These are mostly foreign place names such as "Torino" and "Chicago", but I also included a few musical terms such as "allegro"[8]. As predicted, these words were uniformly pronounced with a long [o:].

As for the high vowels, I found that the pronunciations were highly variable. This suggests that the standard Budapest dialect may not in fact have a length distinction for the high vowel. This possibility has been commented on by Siptár and others. "Most, if not all high vowels *spelt long* are liable to shorten (or are underlyingly short) except in monosyllables, so much so that it may even be the case that their long occurences are due to spelling pronunciation …" (Siptár 1991). Other evidence may come from the observation that orthographic mistakes are quite common for the high vowels relative to the mid and low vowels.

Finally, in addition to the trisyllabic words, I tested the word *babaházba* ('into the doll house'), because this word contains an instance of a word-medial [ɔ], a word-medial [aː] and a word-final [ɔ]. We see that the word-final [ɔ] is significanly longer than the word medial [ɔ]. It is, in fact, very nearly the length of the long vowel [aː]. The first vowel, also [ɔ], is also a little longer than the second vowel. This is probably due to the fact that stress is always word-intitial. Even so, it is still significantly shorter than the long vowel or the word-final vowel.

8. It is for these words, as well as a few of the words with final long [a:], that I sacrificed the template. Some of these words end in a long vowel that does not follow a voiced stop. I choose to include these words anyway, as real Hungarian words of the form …Ba:# or Bo# are rare.

(42) Vowel durations (in ms.) for the word "babaházba".

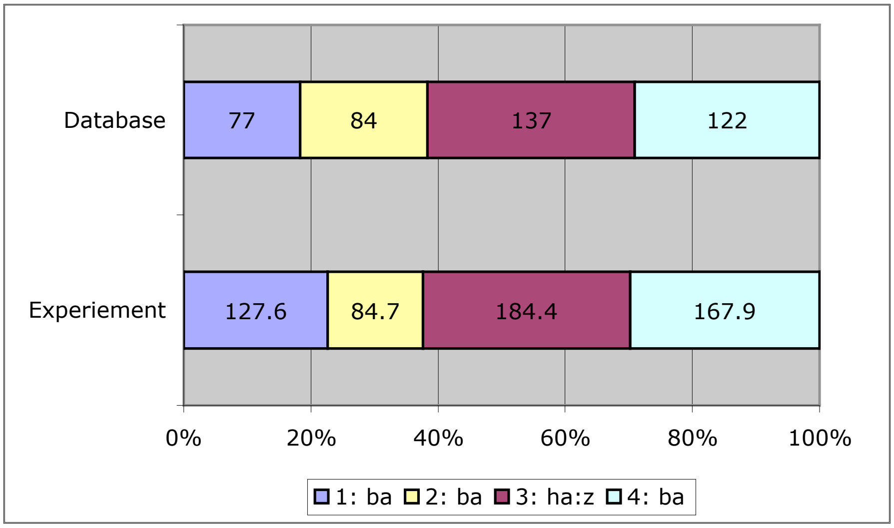


6.2 Support From a Database

Olaszy and contributors[9] have compiled a database of the sound duration structure of 1.5 million Hungarian word forms. Preliminary results from a search through this database confirm the results from my own phonetic experiment. For example, the database contains the form *babaházba*. The duration of the four vowels from the database are compared to the results from the experiment below. The first row of rectangles gives the duration of the four vowels, in order, for the database numbers. That is, the first rectangle represents the duration of the first vowel, and so forth. The second row represents the averages from the experiment and are the same as those given in (42). The numbers inside the boxes represent the duration in milliseconds of the vowel. The length of the boxes represents the relative percentage of that sound.

9. Contributors include Gábor Olaszy, Kálmán Abari, Géza Kiss, and Csaba Zainkó. The site is "Database for a presentation of sound duration-maps of Hungarian words" and the address is http://fonetika.nytud.hu/hitint/index.php?hl=en.

(43) “Babaházba” by Experiment and by Database.



Although the experiment average vowel durations are longer than the durations from the database, this representation shows that relative to the other vowels, each vowel is about the same length. That is, the percent of the combined vowel durations from the database for the long vowel in the third syllalbe is 32.6%. For the experiment, this vowel takes up a suprisingly similar 32.7%. The final vowel in the database is 29% of the total, while the final experiment vowel is 30.7%.

It is useful to also compare the word *babaházba* with the word *baba*, which means ‘doll’[10]. The database contains the word *baba*, and gives the first vowel 71 milliseconds, and the second 120. Clearly, word-final lengthening must be at work. Finally, the form *babát* (‘doll, acc.’) has a 69 ms. first vowel and a 158 ms. long second vowel. This supports my claim that word-final “short” vowels are actually much closer to long vowels in terms of length than to word-medial short vowels.

7 Accounting for “Exceptions”

There are a limited number of forms for which the above analysis does not hold. Siptár and Törkenczy (2000) have compiled a list of such words. I reproduce their data below (slightly modified)(S&T: 172). “-” indicates a morpheme boundary and is not orthographic.

(44) a. balt[ɔ]-nyél ‘hatchet handle’
kef[ɛ]-köto! ‘brush maker’
haz[ɔ]-megy ‘go home’
bel[ɛ]-lép ‘step into it’

b. kuty[ɔ]-szeru! ‘dog-like’
mes[ɛ]-szeru! ‘like a fairy tale’
macsk[ɔ]-féle ‘feline’

10. The vowel in the second syllable does not lengthen before *ház* (‘house’) because this is a compound word. For more discussion, see section 6.

medv[ɛ]-féle 'like a bear'

c. távozt[ɔ]-kor 'on his departure
megérkezt[ɛ]-kor 'on his arrival'
tort[ɔ]-ként 'as a cake'
sört[ɛ]-ként 'as bristles'
péld[ɔ]-képp(en) 'for instance'
mérc[ɛ]-képp(en) 'as a measure'
haz[ɔ]-i 'domestic'
megy[ɛ]-i 'country' (adj.)

d. katon[ɔ]-ság 'army'
feket[ɛ]-ség 'blackness'

In (45), candidate (a) loses because the short, non-high, front, unrounded vowel is not phonetically mid. Candidate (d) meets with a similarly swift death. Candidate (c), the attested form, loses because it does not correspond in length to the base form [k ɛ f ɛ]. Candidate (b) is the false winner.

(45) tableau 7 'brush maker'

/kɛfɛ + køtø:/ [kɛfɛ:]	E = [E]	E: = [e:]	MAX-μ	*LONGV]WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. [kɛfekøtø:]	*!				*		*
b. ☞[kɛfe:køtø:]							*
c. ☹ [kɛfɛkøtø:]					*!		
d. [kɛfɛ:køtø:]		*!					

The source of the exceptionality is clearly the apparent suffixes. Those which do not cause lengthening are few and can be numbered, while the stem has a long final vowel when followed by innumerable other suffixes. The difference with the suffixes in (44) is structural and will be explained according to the alphabetical grouping in (44).

The words in the first group (a) are compounds. Siptár and Törkenczy (2000) comment that although compounds form one domain for stress, they constitute two separate phonological words with respect to vowel harmony.

If each compound member forms its own prosodic word, then a form like *kefekötő* is twice subject to *LONGV]WD, because it was already defined in terms of the prosodic word boundary. The more accurate tableau reflects this in (46).

(46) Tableau 7 -revised
‘brush maker’

PrWd → PrWd PrWd / kɛfɛ + køtø: / [kɛfɛ:]	E=[ɛ]	E:=[e:]	MAX-μ	*LONGV]WD	OO [LENGTH]	OO [ROUND]	OO [HEIGHT]
a. [kɛfe̲køtø:]	*!				*		*
b. [kɛfe̲:̲køtø:]				*!			*
c. ☞[kɛfɛkøtø:]					*		
d. [kɛfɛ̲:̲køtø:]		*!		*!			

Turning now to group (b), *féle* and *szerű* are enclitics, which can be treated in a similar manner as compounds (S&T 2000). The enclitic forms its own prosodic word: [$_{PW}$[$_{PW}$medve][$_{PW}$féle]].

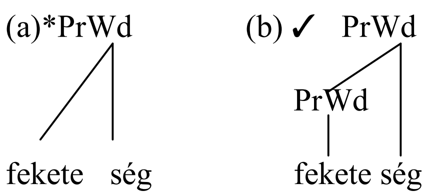
The suffixes in (c) are not enclitics, so it would be surprising if they formed their own prosodic word. Vowel harmony does give us another clue, however. These suffixes do not obey vowel harmony. Examples from (S&T 2000).

(47) No vowel lengthening with *-kor*:
távozt[ɔ]-kor (‘on his departure’)
megérkezt[ɛ]-kor (‘on his arrival’)
No vowel harmony with *–kor*:
megérkezt[ɛ]-kor-i-a̲k (‘those coinciding with his arrival’)
* megérkezt[ɛ]-kor-i-e̲k

It seems likely that if these suffixes are outside of the harmonizing domain they are also outside of the prosodic word domain.

The suffix *ság/ség*, group (d), does, however, harmonize, so it must be within the vowel harmony domain. If the suffix is in some same domain as the stem to which it attaches, it seems necessary for the two parts to make up a prosodic word (48a). But the stem also forms its own prosodic word, so the structure in (b) seems more accurate. Future work may support these structures. Evidence may come from observations of secondary stress or aspiration.

(48)



The suffixes in (c) might also fall into such a structure. If so, they must lack the possibility of alternating forms, so no vowel harmony is possible. Otherwise, they should be analyzed separately from the alternating suffix *ság/ség*. The structural differences are summarized in (49).

(49) Exceptional suffix structures

structure	PPh PrWd PrWd kefe köto!	PPh PrWd Ft medve féle	PPh PrWd σ haza i	PrWd PrWd σ fekete ség	PrWd Ft seg. alma t
meaning	'brush' + 'maker'	'bear' + 'kind of…'	'country' + attributive	'black' + collective	'apple' + accusative
gloss	'brush maker'	'like a bear'	'domestic'	'blackness'	'apple' acc.
type of structure	compound: ProsodicWord	(en)clitic: free clitic	suffix	suffix	suffix

With very little difficulty, then, drawing on the observations of Siptár and Törkenczy, we can satisfactorily account for the exceptional suffixes which do not cause LVL.

8 Final Remarks

By incorporating phonetic processes into our understanding of what constitutes the base string for Output-Output constraints, we can also understand *why* Low Vowel Lengthening occurs in Hungarian. The relative rarity of forms with long, low word-final vowels can be explained by a reranking of MAX-μ over the previously undominated *LONGV]WD. Furthermore, the evidence I have provided in this paper supports Myers' (to appear) and Steriade's (2000) claims about the role phonetic properties play in phonology.

Certainly more work remains to be done. The boundaries of phonetic effects must be explored, and whether, or to what extent, phonetic and phonological features should be distinguished are both important questions.

Finally, I have accounted for Hungarian Low Vowel Lengthening in an Optimality Theoretic framework and have done so by drawing on various universal constraints which show effects in other dimensions of Hungarian. Support for this analysis is drawn from evidence of the general distribution of vowels word-finally, Hungarian pronunciation of foreign words, word-final lengthening, and a phonetics study conducted by the author. These motivations lead me to believe that this account is superior to previous accounts of the phenomenon.

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Database for a presentation of sound duration-maps of Hungarian words:
http://fonetika.nytud.hu/hitint/index.php?hl=en
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