Prosodically driven continuity lenition:
A phonological account of spirantization in Colombian heritage Spanish

By

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ABSTRACT

This dissertation examines the process of lenition, or spirantization, of intervocalic voiced stops /b, d, g/ in heritage Spanish. While spirantization is one of the more extensively studied phonetic and phonological phenomena in Spanish, this study introduces methodological and theoretical advances for the study of heritage phonology. The data come from an understudied variety of U.S. Spanish spoken by heritage speakers of Colombian descent in New Jersey and Florida across three generations.

Previous studies have analyzed linguistic factors such as phoneme, stress, word position, and task type, that mediate voiced stop lenition in monolingual varieties of Spanish (Broś et al., 2021; Carrasco, 2008; Carrasco et al., 2012; Colatoni & Marinescu, 2010; Eddington, 2011; Figueroa, 2016), heritage Spanish (Amengual, 2019; Blair & Lease, 2021; Rao, 2014, 2015), and L2 Spanish (Cabrelli Amaro, 2017; Zampini, 1997, 1998). The present study builds on this research by expanding the variable of word position beyond the binary medial vs. initial distinction to include three prosodic domains: syllable-initial within the word, initial in the minimal prosodic word, and initial in the maximal prosodic word. The results from a reading task and conversation dyad confirm that the linguistic variables of phoneme, stress, prosodic domain, and task type mediate categorical acoustic measures of lenition in heritage Spanish in a way that replicates previous studies' findings for other varieties. Social factors such as generation, order of language acquisition, and speech community are not found to be significant predictors of voiced stop lenition in the corpus of data analyzed here.

Based on the results of the experimental tasks and previous studies on other varieties of Spanish, this dissertation offers a formal analysis in phonetically based Optimality Theory that accounts for domain-medial spirantization as continuity lenition, which, in conjunction with

fortition at domain edges, helps demarcate prosodic constituents for the listener's benefit (Katz, 2016). The analysis makes testable predictions about possible patterns of variation both in and beyond Colombian heritage Spanish. In sum, this dissertation contributes to a growing body of work (Broś et al., 2021; Harper, 2014; Katz, 2016; Katz & Fricke, 2018; Katz & Moore, 2021; Keating, 2006; Kingston, 2008) seeking to flip the traditional narrative that consonantal weakening is primarily a speaker-based phenomenon driven by effort minimization.

Para mis abuelitos:		*For my grandparents:*
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CHAPTER 1: INTRODUCTION

1.1 Introduction

Spirantization is a well-known feature of Spanish segmental phonology in which the voiced stops /b, d, g/ alternate with spirant approximants [β̞, ð̞, ɣ̞] after vowels and certain consonants, yielding a gradient continuum of realizations that differ in relative acoustic intensity and articulatory openness. The process is traditionally understood as either continuancy assimilation or stricture reduction, whose main functional motivation is a speaker-based minimization of articulatory effort. An alternative view highlights the perceptual basis of the alternation by zooming out far enough to fully appreciate the role of the listener: spirantization of domain-medial consonants vs. fortition at domain edges are complementary processes whose function is to convey to the listener that the current prosodic constituent is continuing or a new one is beginning, respectively (Keating, 2006; Kingston, 2008). Katz (2016) analyzes domain-medial spirantization as *continuity lenition:* greater signal intensity is maintained inside a prosodic constituent when the constituent's boundaries are aligned with auditory disruptions of lesser intensity. Using phonetically-based constraints in Optimality Theory, Katz formalizes thresholds of segmental intensity and duration such that a single constraint drives both medial lenition and edge fortition in a given prosodic domain.

The aim of this dissertation is to examine, from a phonetically informed phonological perspective, the production of intervocalic voiced stops in a U.S. Spanish variety that has yet to be the focus of experimental investigation. This study introduces novel quantitative data and generalizations from U.S. heritage speakers of Colombian descent, along with a generalized linear mixed-effects regression analysis of the relevant linguistic variables that mediate intervocalic voiced stop lenition, which include phoneme, stress, prosodic domain, and task type. Based on these results, and informed by previous research on spirantization in Spanish, we present a formal analysis of prosodically driven continuity lenition that not only accounts for the Colombian heritage experimental data but also makes predictions about possible patterns of surface variation, some of which are attested in other Ibero-Romance varieties such as Judeo-Spanish.

The remainder of this chapter reviews the literature on the main components placed under focus by this dissertation. We start with a review of the phonological process of spirantization of voiced stops in Spanish (Section 1.2), followed by an overview of the population of study (Section 1.3). Next, we position the need for this study in the growing field of heritage phonology (Section 1.4) and present the previous literature of relevant studies on voiced stop lenition in monolingual, heritage, and second language (L2) varieties of Spanish (Section 1.5). Finally, Section 1.6 presents the motivating research questions, followed by the organization of the dissertation (Section 1.7) and conclusion of the chapter.

1.2 Voiced stop lenition

One of the more widely studied phenomena in Spanish phonology is the spirantization of voiced stops /b, d, g/. The basic distribution of the stop (1) and approximant (2) allophones by phonological context is as follows: stops are pronounced after a pause, after a nasal, and for /d/, after a lateral, while approximants appear elsewhere. These representative, broad transcriptions illustrate complementary distribution at the word level.

(1) Stops: [b, d, g]

After a pause	*ballena*	[‖baˈ.ʝ̞e.na]	‘whale’
	dedo	[‖ˈde.ð̞o]	‘finger’
	gato	[‖ˈɡa.to]	‘cat’
After a nasal	*enviar*	[emˈ.bi̯aɾ]	‘to send’
	lindo	[ˈlin̪.do]	‘cute’
	mango	[ˈmaŋ.ɡo]	‘mango’
For /d/: after a lateral	*caldo*	[ˈkal̪.do]	‘soup’

(2) Approximants: [β̞, ð̞, ɣ̞]

After a vowel	*lobo*	[ˈlo.β̞o]	‘wolf’
	dedo	[ˈde.ð̞o]	‘finger’
	lago	[ˈla.ɣ̞o]	‘lake’
After a glide	*traigo*	[ˈtɾai̯.ɣ̞o]	‘I bring’
	deuda	[ˈdeu̯.ð̞a]	‘debt’
After a continuant consonant	*árbol*	[ˈaɾ.β̞ol]	‘tree’
	verde	[ˈbeɾ.ð̞e]	‘green’
	carga	[ˈkaɾ.ɣ̞a]	‘load’
	esbelto	[ezˈ.β̞el̪.to]	‘slim’
	desde	[ˈdez.ð̞e]	‘since’
	rasgo	[ˈraz.ɣ̞o]	‘feature’
For /b, ɡ/: after a lateral	*alba*	[ˈal.β̞a]	‘dawn’
	algo	[ˈal.ɣ̞o]	‘something’

The same alternation between stops and approximants is also found across word boundaries as long as no pause intervenes, e.g. *un vino* [ˈum ˈbi.no] ‘a wine’, *ese vino* [ˈe.se ˈβ̞i.no] ‘that wine’, *hay vino* [ˈai̯ ˈβ̞i.no] ‘there is wine’, [loz ˈβ̞i.nos] ‘the wines’, [el ˈβ̞i.no] ‘the wine’.

Many studies on monolingual Spanish have focused on the underlying representations and phonological derivations that motivate this distribution (Harris, 1983; Lozano, 1979; Mascaró, 1984; among others) as well as on variation in the stop ~ approximant alternation across Spanish dialects (Amastae, 1986; Lewis, 2001). In highland Colombian Spanish, in addition to other varieties in Central America, there is evidence of occlusion after all consonants and glides (Hualde, 2014; Quilis, 1999). The phonological analyses have focused on theoretical motivations based on effort (Kingston, 2008; Kirchner, 1998; 2001; Piñeros, 2002), fortition (Baković, 1994; Colina, 2016, 2020; Martínez-Gil, 1997, 2001), perception (Broś et al., 2021; Harper, 2014; Katz, 2016; Kingston, 2008) and intensity (Colatoni & Marinescu, 2010; Cole et al., 1999; Eddington, 2011; Lavoie, 2001; Lewis, 2001; Ortega-Llebaria, 2004). A more detailed review of the literature pertaining to the phonological analysis of voiced stop lenition in Spanish can be found in Chapter 4. Given the relatively few studies on Spanish heritage phonology in the field, the purpose of this dissertation will be to return to the phonological analysis of voiced stop lenition in Spanish based on the phonetic analysis of data produced by heritage speakers.

1.3 Background

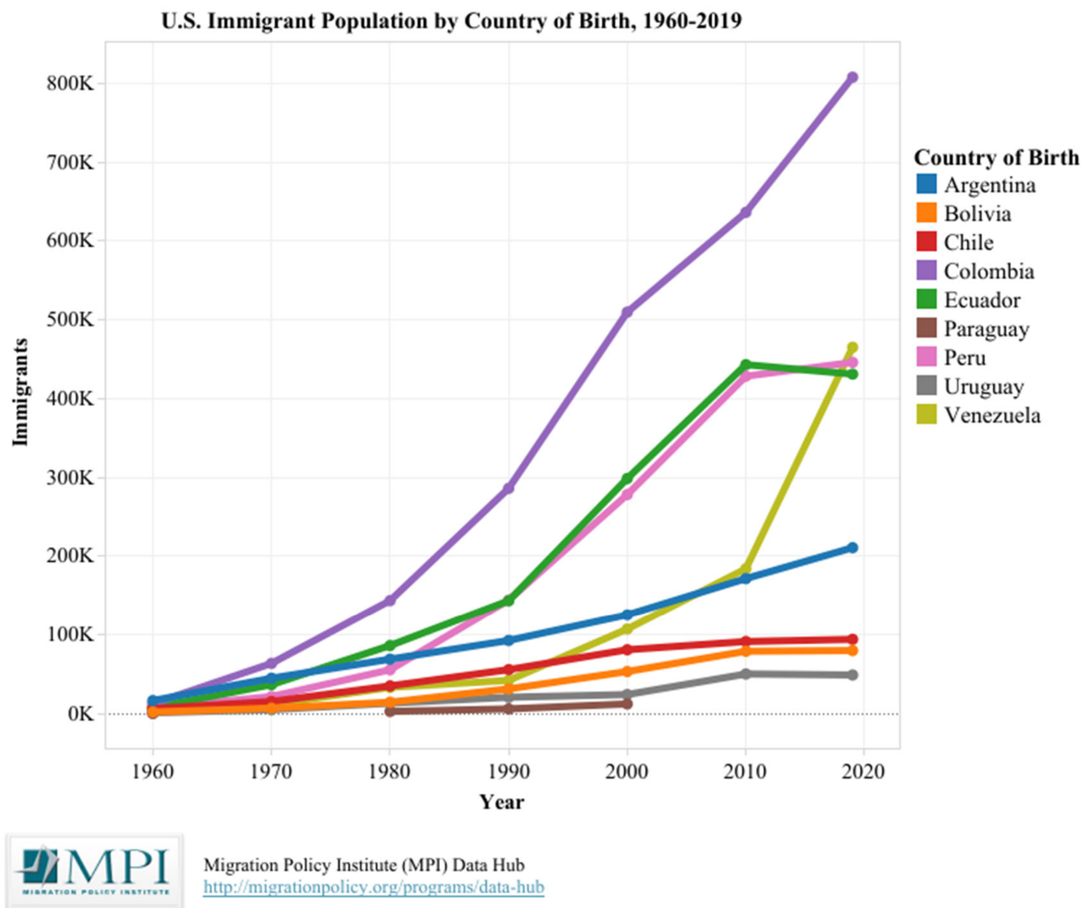
This section presents the background literature relevant to the population of speakers analyzed in this dissertation, heritage speakers of Spanish of Colombian descent in the U.S.

1.3.1 The Colombian diasporic population in the U.S.

In order to understand the importance of Spanish heritage language speakers in the U.S., it is essential to look at the population of Spanish speakers. Currently, the U.S. census reports the Hispanic population at 56.6 million and the largest ethnic/racial minority at 17.6% of the U.S. population. In terms of population growth, the census estimates that by the year 2060 there will be 119 million Hispanics in the U.S., or 28.6% of the population. With only 34.5% of Hispanics identifying as foreign-born in 2015, many of the current and future Hispanic population will be born in the U.S. Despite a growing population, the language maintenance past the third immigrant generation is still in question with the rate of Spanish use in the home dropping (López, et al., 2017). Out of the growth of the Spanish speaking population in the U.S. has emerged the field of Spanish heritage language research. The present study focuses the analysis specifically on speakers of Colombian heritage in the U.S.

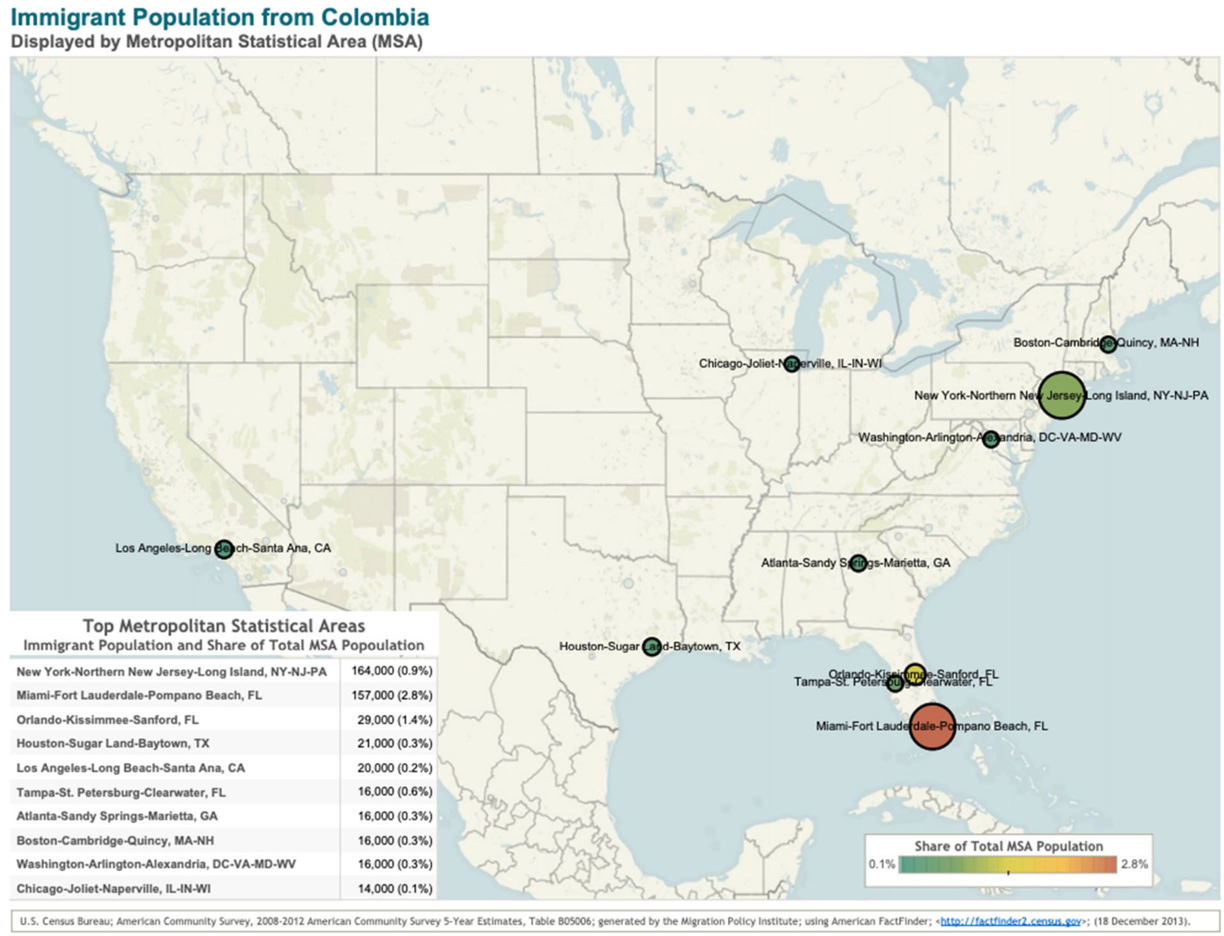
Colombians in the U.S. make up 2% of the Latinx population according to the 2017 American Community Survey from the U.S. Census and are historically the largest immigrant group from South America (Migration Policy Institute, 2015). Figure 1.1 shows the immigration trends from Spanish-speaking countries in South America from 1960-2019.

Figure 1.1. U.S. Immigration population by country of birth, South America, 1960-2019



In the U.S., the Colombian diasporic population resides mainly, "…in the South (51%), mostly in Florida (33%), and the Northeast (32%), mostly in New York (14%) and New Jersey (11%)," (López, 2015) as shown in Figure 1.2 (Migration Policy Institute, 2021).

Figure 1.2. Immigrant population from Colombia in top metropolitan areas



Source: MPI analysis of 2010-12 ACS, pooled.

While Colombians make up the largest immigrant group from South America, they do not constitute the largest community in any major metropolitan area. In regard to the speech community, Lipski (2008) notes that this geographic distribution can have an effect on dialect retention in the U.S.:

> "The large Colombian and Ecuadoran populations are also striking, especially considering that these Hispanic groups do not form coherent neighborhood-based speech communities as do the more populous groups (as well as Hondurans and Nicaraguans in some cities). Moreover, Colombians and Ecuadorans in the United

> States come from a broad cross-section of geographical areas and dialect zones within their respective countries, thus making the retention of Colombian or Ecuadoran Spanish in the United States less viable than with many of the other varieties" (Lipski, 2008: 9).

There have been many studies on Colombian Spanish dialectology and numerous variation studies on U.S. Colombian Spanish. Orozco (2018) provides an extensive study of Colombian Spanish in Barranquilla and in New York City in particular on the expression of futurity, nominal possession expression, and variable subject personal pronoun expression. Hurtado (2001) studies variable personal pronouns of Colombian speakers in Miami-Dade County. Otheguy et al. (2007) include Colombian speakers in their large-scale analysis of dialectal contact in New York City through the study of subject pronoun use. However, Colombian heritage speakers of Spanish are still an understudied population of linguistic studies, and rarely the focus of a phonetic or phonological study.

1.3.2 Spanish as a heritage language

The participants in the present study are of Colombian descent in the U.S. and acquired Spanish as a first language or learned both English and Spanish from birth. This study will apply the terms *heritage* speaker and *bilingual* while referring to speakers who grew up in the U.S. and learned Spanish in the home or community. Initial publications on Spanish heritage language research focused on identifying and defining heritage language speakers predominantly for pedagogical purposes. The various definitions of these speakers demonstrate the heterogeneity of the population of heritage speakers and the numerous characteristics of these speakers that make it challenging to define. Valdés (2001) defines heritage speakers as "a student who is raised in a home where a non-English language is spoken by one who speaks or merely understands the heritage language, and who is to some degree bilingual in English and the heritage language" (1). While this definition applies principally to those in a language classroom, many view this definition as narrow in scope as it does not include those with a heritage motivation or personal connection to a non-majority language (Beaudrie & Fairclough, 2012; Potowski, 2014; Wiley, 2001). Broader definitions, such as that by Fishman (2001), extend the definition of heritage learners to include those who have a personal or heritage connection with a non-majority language, without the requirement of linguistic ability. Other studies have focused on defining various levels of heritage language learners based on linguistic ability for pedagogical and placement purposes (Valdés, 1997; Carreira, 2004). Other accepted definitions that attempt to encompass heritage speakers as a diverse group of speakers of minority languages defined as those who

> "experienced a relatively extended period of exposure to the language, typically during childhood, through contact with family members or other individuals, resulting in the development of either receptive and/or productive abilities in the language, and varying degrees of bilingualism" (Beaudrie & Ducar, 2005).

Many initial studies also employed the other terms such as bilingual, quasi-native speaker, Chicano bilingual (Valdés & Geoffrion-Vinci, 1998), Spanish Native Speaker (Villa, 2002) while the term *heritage* was officially adopted by ACTFL (1996). However, of important note is that heritage speakers do not use that term to self-identify preferring a variety of labels depending on various sociolinguistic factors (Villa & Villa, 1998).

Early research on Spanish as a heritage language examined the pedagogical needs in contrast to second language learners and monolingual speakers. Grosjean (1998) describes bilingualism as a continuum, demonstrated in (3). On each end of the spectrum is a monolingual language ‘A’ or ‘B’ with varying levels of language dominance in between with the completely balanced ‘ab’ bilingual in the center who is proficient in both languages equally across all registers and contexts. Valdés (2001) applies this concept to the heritage speaker population noting that this is likely to be impossible as one person cannot live two separate lives simultaneously.

(3) A Ab ab aB B

Furthermore, the mere question of language dominance does not take into account the range of agency across registers or situations that require different levels of language skills. This concept of language dominance as being is still applied to current research in conjunction with language backgrounds. More recently, an assessment called the Bilingual Language Profile (BLP) has been designed specifically to take sociolinguistic factors and language history into account in order to measure language dominance among bilinguals (Birdsong, et al., 2012).

The conceptualization of bilingualism as a continuum is further broken down into linguistic abilities and demographic features that categorize students into profiles that can be identified in a heritage language classroom (Carreira, 2004; Valdés, 2000). One of the main issues in defining heritage speakers is the ability to capture the heterogeneity of the population. Not only are the identities of the speakers multi-dimensional, but the heritage language itself is heterogeneous in its varieties and registers.

One line of study of heritage speakers has focused on the incomplete acquisition of Spanish. This deficit-focused perspective has been criticized for numerous reasons (Nagy, 2015; Otheguy, 2016). The issue with comparing heritage speakers (with possibly little or no formal education in Spanish) to monolingual or monolingually-raised speakers with education in Spanish is that the varieties assumed of the heritage speaker do not reflect the variety of Spanish spoken in their home or community. The language acquired by these bilinguals does not mirror the context of the monolingual or standardized variety used in linguistic tests, leading researchers to call the language acquisition of these speakers *incomplete* or *deficient*. However, these terms are highly problematic in a number of ways. Primarily, the linguistic outcome of acquisition by a second-generation or heritage speaker is not to speak like a standard-monolingual speaker. The "non-target attainment" is to say that the language acquired in a naturalistic setting in a bilingual context is incomplete compared to a monolingual context. Otheguy (2016) points out that generations will acquire different grammars than the previous generation, further rendering these comparisons futile.

Furthermore, the use of "standardized" Spanish as an indicator of completeness neglects the dialectal variation that may be present in the speech community of the heritage language learner (Fairclough, 1992). While one form may be conceived as standard or correct, it does not mean that it reflects the possible variation of other stigmatized or un-educated speech of the first generation. Finally, the concept that heritage speakers are not native speakers does not allow for fluidity and heterogeneous experiences of U.S. bilinguals. Performing at "target-like" levels on a standardized test does not account for the variability of acquisition in different bilingual contexts in what Otheguy calls "differently evolved grammars." Overall, the concept of incomplete acquisition is heavily flawed, but continues to be prevalent in many studies on the grammar of U.S. bilinguals. These studies that consider the monolingual speaker as the ideal speaker, or the ultimate goal of bilingual proficiency, which is unrealistic and virtually unattainable. Valdés (2001)'s initial description of the bilingual continuum acknowledges the rarity of the ideal bilingual who is capable of proficiency across registers and contexts in both languages equally. Zentella (2016) metaphorically describes this perspective by stating, "… bilinguals should not be held to monolingual standards, as if they are two monolinguals joined at the tongue," (16). Rao (2020: 446) presents the argument that comparisons between bilinguals who are heritage speakers and those who immigrated at a later age to the U.S. are more insightful for understanding the influences of language contact and childhood experiences than apples-to-oranges comparisons to speakers who do not use language in a bilingual context. More recent research, including the present study, has moved away from the 'monolingual-as-standard' concept by reporting findings from heritage speakers without positioning them as a deficit in relation to the monolingual speaker.

1.4 Heritage phonology

The field of heritage language phonology is a relatively new one. Polinsky and Kagan (2007) acknowledge that not much is known regarding the phonological representation of heritage speakers, "likely due to the fact that heritage speakers generally sound so nativelike – one could easily imagine that there would be no differences in phonological representations between the heritage language and the baseline, although that remains to be shown" (378). The assumption that they sound more nativelike is seen as an advantage compared to an L2 speaker. However, this assumption does not take into consideration the heterogeneity of the heritage speaker population and the various factors involved in phonological acquisition. Studies of other systems demonstrate the similarities and differences of linguistic features among various profiles of heritage and monolingual speakers. For instance, studies on morphosyntactic structures of heritage speakers are much more common (Lynch, 2008; Montrul, 2004; Silva-Corvalán, 1994; among others). Rao and Ronquest (2015) call for more extensive research on the phonetic and phonological features of heritage speakers, as most current studies of phonological issues in Spanish compare data from monolingual or L2 speakers. Ronquest and Rao (2018) and Rao (2020) provide an extensive review of the current studies and remaining gaps in heritage phonology research. The main division of studies that have been done in heritage phonology can be categorized by consonants such as stops (Au et al., 2002; Au et al., 2008; Amengual, 2019; Knightly et al., 2003; Rao, 2014, 2015), liquids (Amengual, 2016, 2018; Barlow, 2014; Henriksen, 2015; Kim & Repiso-Puigdelliura, 2020; Kissling, 2018), and fricatives (O'Rourke & Potowski, 2016; Van Buren, 2017). Other areas of study are vowels (Alvord & Rogers, 2014; Mazzaro et al., 2016; Ronquest, 2012, 2013; Willis, 2005), syllabification (Chappell, 2018; Shelton et al., 2017), lexical stress (Hoot, 2012; Kim, 2014, 2015, 2020), and prosody and intonation (Alvord, 2010; Kim, 2019; Kim & Repiso-Puigdelliura, 2021; Rao, 2016; Robles-Puentes, 2014). Ronquest and Rao (2018) suggest expanding research methods to both laboratory (careful) and spontaneous speech styles to understand speaker behavior in both controlled experimental conditions and more natural language settings. Notably, Rao (2020) acknowledges that formal generative frameworks, such as Optimality Theory, have not yet been applied to heritage speaker data, at least within the U.S. Spanish context.[1]

1.5 Previous studies on voiced stop lenition

An extensive literature on Spanish spirantization provides the jumping-point for further investigation into an understudied variety of U.S. Spanish. While many of these studies include analyses of phrase-initial and/or postconsonantal voiced stops, the focus in reviewing these

[1] Based on data from German-Spanish bilinguals living in Germany, Lleó (2018: 96) suggests that the difference in application of spirantization between the two languages stems from different rankings of constraints in Optimality Theory. Cases of phonological transfer from German into heritage Spanish can include the transfer of constraint rankings, which starts at around age 2;6 as bilinguals begin to produce fewer and fewer approximant allophones.

previous studies will be on the linguistic variables affecting allophony of intervocalic voiced stops in particular. This section reviews relevant works on intervocalic voiced stop lenition in monolingual Spanish (Section 1.5.1), heritage Spanish (Section 1.5.2), and L2 Spanish (1.5.3).

1.5.1 Monolingual varieties of Spanish

Phonetic studies of monolingual Spanish varieties have analyzed the linguistic factors that mediate voiced stop lenition and its allophonic variation. A more detailed review of the relevant results and linguistic variables from the following studies in this subsection appears in Chapters 2 and 4.

In an early study of Spanish obstruents, Martínez-Celdrán (1984) classifies three degrees of articulatory tension: high (voiceless stops and fricatives), medium (voiced stops, with or without a release burst), and low (pure approximants). Acoustic analysis reveals that the degree of tension is correlated positively with duration but negatively with intensity: obstruents involve less articulatory tension as they become shorter and more intense acoustically. More recently, Martínez-Celdrán and Regueira (2008) replicate the these findings based on the approximant allophones of voiced stops in Galician, an Ibero-Romance language spoken in northwestern Spain that has spirantization patterns similar to those of Northern-Central Peninsular Spanish.

Two studies comparing Spanish varieties with American English include Lavoie's (2001) investigation of consonantal weakening in Mexican Spanish and Parker's (2002) investigation of the acoustic correlates of sonority, which presents data from Colombian Spanish. Despite some minor discrepancies involving specific segments, these studies generally support the relative intensity relationships among major consonant classes as proposed by Martínez-Celdrán (1984) and subsequently confirmed by Martínez-Celdrán and Regueira (2008).

Ortega-Llebaria (2004) studies intervocalic spirantization of /b/ and /g/ with data from five speakers of Caribbean Spanish varieties and five American English speakers. Using continuous measures of RMS-amplitude ratio, with a 0 indicating stop closure and 1 meaning a more vowel-like production, she finds that phonetic factors of stress and vowel context impact the degree of lenition for both phonemes. Additionally, individual variation among both Spanish and English speaker groups demonstrates that lenition applies less frequently when phonemic contrasts are more likely to be jeopardized, e.g. the difference between English /b/ and /v/ is phonologically contrastive in English, whereas Spanish lacks phonemic /v/ or /β̞/.

Carrasco (2008) and Carrasco et al. (2012) analyze the allophonic distribution of voiced stops in Costa Rican and Madrid Spanish in various phonetic contexts. They test for weakening in two dialects, by place of articulation, preceding segment, word-position (initial or medial), lexical stress, and speech style. These studies confirm that Costa Rican Spanish is more conservative in the production of voiced stops compared to Madrid Spanish, with lower intensity ratio values indicating relatively less spirantization in each context in the former variety. In word-medial intervocalic position, speakers from both dialects lenite, but Costa Rican Spanish speakers produce more stops when the segment occurs in word-initial position than Madrid speakers do.

Colatoni and Marinescu (2010) study stop weakening in Argentine Spanish. They confirm that voiced stops lenite more than voiceless stops, with preceding and following vowel, stress, and place of articulation affecting the degree of lenition among voiced stops. Eddington (2011) provides further evidence that phonetic context, stress, and word boundaries are significant predictors of voiced stop lenition. In this study of speakers from seven different varieties of Spanish, there is more lenition in the intervocalic context, in unstressed syllables, and the least lenition after a pause or in word-initial position intervocalically. Regarding Chilean Spanish, Figueroa (2016) presents a study on both production and perception of voiced stop lenition. Results from this variety confirm those of previous research showing that spirantization is favored in intervocalic position and informal speech tasks. There is also an effect of high-frequency words.

In an analysis of Gran Canaria Spanish, Broś et al. (2021) examine postvocalic lenition of voiceless and voiced stops. Using gradual measures of duration, intensity, and harmonics-to-noise ratio, they analyze the phonological effects and phonetic variables that govern lenition, as manifested in the voicing of voiceless stops, e.g. *caseta* [kaˈ.se.da] 'tent', and the spirantization and deletion of voiced ones, e.g. *helado* [eˈ.la.ð̞o] ~ [eˈ.la.o] 'ice cream'. Similar to previous studies, they include place of articulation, following environment, preceding vowel, stress, and word-position as linguistic factors. The results show a hierarchical organization of obstruents from voiceless stops to voiced approximants scaled on six total degrees of aperture, with gradient differences demonstrating stress and word position effects along the hierarchy. Although lenition processes yield partially overlapping underlying-to-surface mappings in this dialect, the phonological contrast between voiceless and voiced stops is largely maintained and, therefore, is only incompletely neutralized, if at all.

1.5.2 Heritage Spanish

In a cluster of studies on the impact of early childhood exposure to language, Au et al. (2002), Knightley et al. (2003), and Au et al. (2008) examine the long-term effects on a series of linguistic variables in adult heritage speakers. These studies analyze voiced stop lenition in conjunction with other measures of production and comprehension of childhood slang, voice onset time of voiceless stops, accent rating of voiceless and voiced stops, morphology production (gender and number agreement), and grammaticality judgements of morphosyntactic errors. They find that early childhood exposure to the language leads to a phonetic and phonological advantage over late L2 learners of Spanish.

Rao (2015) analyzes the production of /b, d, g/ among eight heritage speakers in the Midwest (also see Rao, 2014, for an earlier study focusing entirely on the bilabial). He examines intervocalic contexts word-internally and across word-boundaries, as well as by syllable stress, based on acoustic data from the reading of a word list and paragraph, and from spontaneous speech in an open ended question interview. The data were coded into categorical manners of production: Pure Approximant [β̞, ð̞, ɣ̞] (PA), Tense approximant [b̥, d̥, g̥] (TA), or Stop [b, d, g] (Rao, 2015: 55-56). Rao finds that individual differences and linguistic background have an influence on voiced stop production. Those participants who had a stronger connection with Spanish as children show a more native-like production of approximants, while those with less exposure to the language produce less native-like realizations, although this generalization does not hold across the board for everyone. Regarding the difference between word-internal and word-initial positions, the type of task (reading vs. spontaneous speech) is not reported to be a significant predictor of PAs. However, there is a connection between approximant production and articulatory strengthening in domain-initial position, which suggests that heritage speakers are less likely to produce PAs at a word boundary.

Amengual (2019) compares /b, d, g/ realizations among two groups of heritage speakers (simultaneous and sequential bilinguals) and L2 speakers. This study takes a continuous measure of the degree of spirantization based on the intensity difference (*IntDiff*): "the more lenited the consonant, the smaller the *IntDiff* (dB) is expected to be with respect to the following vowel" (Amengual, 2019: 8). Results point to an effect of early exposure for sequential bilinguals (exposed to Spanish before English) compared to simultaneous bilinguals with respect to lenition of intervocalic stops. All three groups are similar in the production of phrase-initial voiced stops, suggesting that they possess an understanding of the phonological distribution of lenition, with heritage speakers producing more lenited stops in intervocalic position.

Blair and Lease (2021) follow the same methodological categorization of PA, TA, Stop allophones of voiced stops, as produced by 20 heritage speakers of Spanish from four generations. In addition to generation, participants' age of language acquisition and the order of acquisition were considered to be potential social factors relevant to the distinction between simultaneous and sequential bilingualism. Other linguistic factors include syllable stress, preceding and following vowel height, and the cognate status of the word. The results of this study find generation to be a significant factor in disfavoring lenition for all three phonemes, while age and order of acquisition were not significant. The only significant linguistic variable was phonetic context of preceding vowel height for all phonemes and following vowel height for /b/.

1.5.3 L2 acquisition of Spanish spirantization

Compared to research on the acquisition of intervocalic spirantization by heritage speakers, such research involving L2 learners is relatively more extensive (Alvord & Christiansen, 2012; Díaz-Campos, 2004; Rogers & Alvord, 2014). Building on the early studies by Zampini (1994, 1997, 1998) and González-Bueno (1995), Face and Menke (2009) and Cabrelli Amaro (2017) take a more modern look at the acquisition of /b, d, g/ lenition in L2 Spanish using spectrographic analysis to categorize and measure learner productions instrumentally.

In L2 phonological acquisition research, Zampini (1997) analyzes the acquisition of postvocalic spirantization by L1 English-speaking learners of L2 Spanish in the 2nd and 4th semester levels. She finds a strong preference for spirantization to apply in word-medial contexts.

Both groups are able to produce spirant approximants at the level of the prosodic word, and to some extent the clitic group. More advanced students are able to produce word-initial spirants in medial position within phonological phrase. Following the subset principle, learners are hypothesized to acquire spirantization in a given prosodic domain once they have already acquired it at all lower, more restrictive domains. Zampini (1997, 1998) suggests that this principle can be applied to L2 acquisition of voiced stop lenition in relation to the prosodic hierarchy (Nespor & Vogel, 1986), as shown in Figure 1.3 (for more discussion and a revision version of the prosodic hierarchy, see Chapter 4).

Figure 1.3. The prosodic hierarchy

Phonological utterance

Intonational phrase

Phonological phrase

Clitic group

Prosodic word

Foot

Syllable

According to the hypothesis, lenition should be restricted to the Syllable level domain in word-medial position in the beginning stages of acquisition but then gradually move up the hierarchy in later stages. Zampini (1997: 216) assumes that the maximal prosodic domain for spirantization in general monolingual Spanish is the intonational phrase.

In their study of L2 Spanish students across three university levels (fourth semester, graduating Spanish majors, and Ph.D. students), Face and Menke (2009) find further evidence of a distinction between the acquisition of word-internal and word-initial spirantization. There is an overall increase in spirant approximants as level of instruction increases. However, participants still maintain a clear distinction between both prosodic positions, leniting more frequently in word-medial intervocalic contexts.

Using continuous measurements of acoustic intensity data from university-level learners of Spanish, Cabrelli Amaro finds some support for Zampini's (1997, 1998) hypothesized relationship between spirantization and prosodic domains in L2 acquisition. However, Cabrelli Amaro finds no statistical evidence of differential acquisition in the prosodic word vs. the clitic group. She recasts the latter domain within Itô and Mester's (2007, 2009a,b) theory of the extended prosodic word by recursively adjoining unstressed function words to the adjacent prosodic word. Learners are found to acquire intervocalic spirantization first across the syllable boundary within the minimal prosodic word (ω_{min}), as shown in Figure 1.4 for /d/ in unstressed and stressed syllables in *duda* 'doubt' and *rodilla* 'knee'.[2] No significant differences are observed for voiced stops at the minimal prosodic word boundary in Figure 1.5, *su dinero* 'his/her money' and *la dicha* 'good fortune', compared to the maximal prosodic word boundary (ω_{max}) in Figure 1.6, *chica*

[2] In these prosodic representations, we omit the foot domain. The symbol ω is subscripted only in the case of recursion, where 'min' and 'max' denote the lowest and highest prosodic word, respectively. In the absence of recursive adjunction, a single ω can be considered both the lowest and highest prosodic word simultaneously. The symbol φ denotes the phonological phrase domain and σ, the syllable.

dudosa ‘suspicious girl’ and *vida digna* ‘worthy life’, which suggests that only two domains—the syllable and the prosodic word—mediate the L2 acquisition of Spanish spirantization. These results diverge from those reported by Zampini (1997, 1998), who argues that L2 learners can be sensitive to the difference, acquiring voiced stop lenition across the minimal word boundary before acquiring it across the maximal boundary. The present study adopts the distinction between minimal and maximal projections of the prosodic word in order to test for variation in lenition frequency and degree across both types of word-initial boundary, in addition to the word-medial syllable-initial context.

Figure 1.4. Voiced stops at the syllable boundary within the prosodic word

Figure 1.5. Voiced stops at the minimal prosodic word boundary

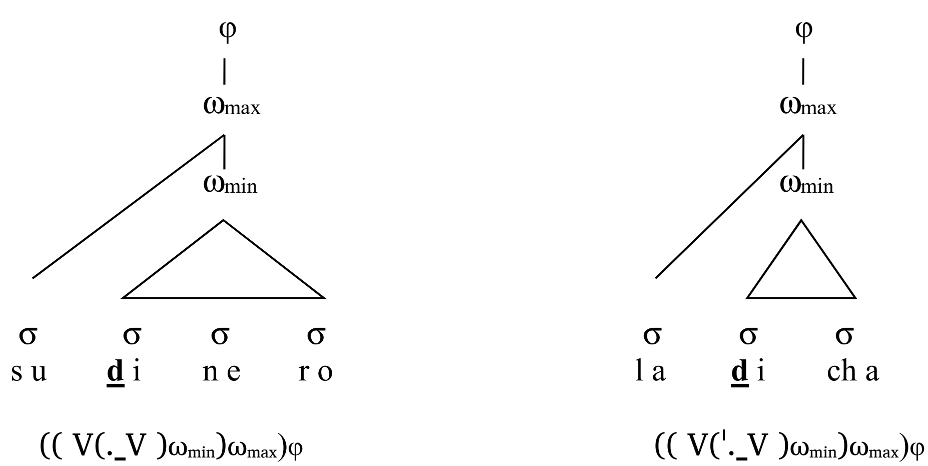
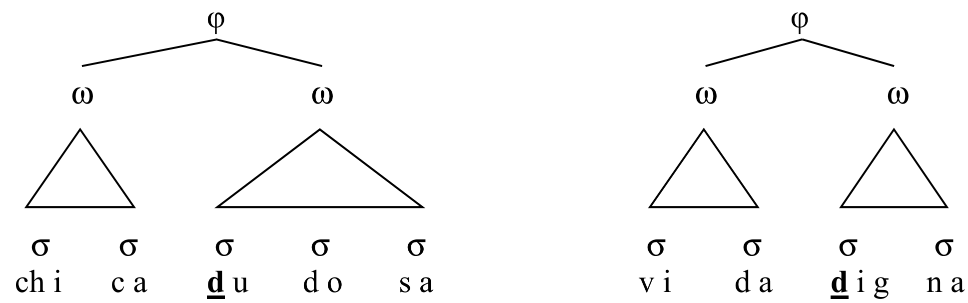


Figure 1.6. Voiced stops at the maximal prosodic word boundary



((V)ω(._V)ω)φ   ((V)ω(ˈ._V)ω)φ

A significant theoretical contribution of Cabrelli Amaro's (2017) study is her formal analysis of the L2 acquisition pathway of spirantization, couched within the constraint-based Optimality Theoretic framework (Prince & Smolensky, 2004). In particular, Cabrelli Amaro applies the Gradual Learning Algorithm (Boersma & Hayes, 2001) to model stochastic variation in the acquisition of the intervocalic stop ~ approximant alternation according to the prosodic hierarchy. Her analysis shows that L2 learners can acquire the constraint ranking of the target grammar, although even advanced learners of near-native proficiency do not completely attain the highest degrees of lenition exhibited by a native control group. Adopting a possible approach to prosodically mediated spirantization sketched by Kingston (2008: 28), Cabrelli Amaro assumes that the input contains voiced stops, which are mapped to output approximants depending on the ranking of markedness and faithfulness constraints. A markedness constraint against postvocalic voiced stops, *VOICED STOP/V_, interacts with positional faithfulness constraints on the feature [continuant] that are relativized to the onset of prosodic constituents, IDENT(continuant) ONSET PW and IDENT(continuant) ONSET SYLL.

The ranking in tableau (4) corresponds to the interlanguage grammar at the early stages of L2 acquisition, where even beginning learners spirantize syllable-initial word-medial voiced stops. The postvocalic stop of input /duda/ maps faithfully to the output in candidate (4)a, which fatally violates *VOICED STOP/V_, as indicated by the exclamation point placed after the candidate's violation mark. The pointing hand shows that (4)b is the optimal output because the faithfulness constraints violated by the /d/ → [ð̞] mapping, the positional IDENT(continuant) ONSET SYLL and the context-free IDENT(continuant), are both ranked lower in the grammar. However, the same unfaithful mapping is blocked at prosodic word boundaries, whether minimal or maximal. Spirantization of the word-initial postvocalic stop of the input /ʧika dudosa/ in output candidate (4)d fatally violates IDENT(continuant) ONSET PW, which ranks higher than *VOICED STOP/V_.

(4)

Beginning L2 learners	IDENT(continuant) ONSET PW	*VOICED STOP/V_	IDENT(continuant) ONSET SYLL	IDENT(continuant)	*APPROXIMANT/V_
a. /duda/ → ˈdu.da		*!			
☞ b. ˈdu.ð̞a			*	*	*
☞ c. /ʧika dudosa/ → ˈʧi.ka duˈ.ð̞o.sa		*			*
d. ˈʧi.ka ð̞uˈ.ð̞o.sa	*!		*	*	**

Tableau (5) depicts the ranking that generates the target distribution of spirantization at both the syllable and prosodic word levels. In the later stages of L2 acquisition, *VOICED STOP/V_ comes to outrank IDENT(continuant) ONSET PW, as in the target language, and the word-initial voiced stop of /ʧika dudosa/ is now forced to lenite to in (5)d. Within the Gradual Learning Algorithm, learner variability in speech production can be modeled by assigning each constraint a probability curve along which a specific point is randomly selected at evaluation time.

Intermediate and advanced learners who appear to have acquired the target ranking of *VOICED STOP/V_ » IDENT(continuant) ONSET PW still show enough variation to suggest that the ranking remains in flux. For learners who produce relatively fewer approximants across word boundaries, the probability curves of these two constraints are minimally overlapped, such that the selection points are less likely to result in the ranking of *VOICED STOP/V_ » IDENT(continuant) ONSET PW. For learners who spirantize more frequently across word boundaries, the constraint curves overlap even more, which increases the probability of selecting the ranking that favors spirantization at the prosodic word boundary.

(5)

Intermediate/advanced/control group		*VOICED STOP/V_	IDENT(continuant) ONSET PW	IDENT(continuant) ONSET SYLL	IDENT(continuant)	*APPROXIMANT/V_
a. /duda/ →	ˈdu.da	*!				
☞ b.	ˈdu.ð̞a			*	*	*
c. /ʧika dudosa/ →	ˈʧi.ka duˈ.ð̞o.sa	*!				*
☞ d.	ˈʧi.ka ð̞uˈ.ð̞o.sa		*	*	*	**

While this analysis accounts for the asymmetry between word-medial and word-initial spirantization rates across different L2 acquisition stages, some open questions remain. First, only two allophone categories, stop vs. approximant, are considered in output candidates. How can this approach incorporate the finer-grained distinction between Pure and Tense approximant categories assumed in recent studies of heritage Spanish spirantization (Rao, 2014, 2015; Blair & Lease, 2021)? Second, Cabrelli Amaro assumes voiced stops in the input and uses positional faithfulness to block spirantization. However, stipulating noncontinuants in the input goes against a core tenet of Optimality Theory known as Richness of The Base, which forbids placing restrictions directly on input representations (Prince & Smolensky, 2004: 205, 225; McCarthy, 2002: 70-71, 2008: 88-95). In fact, ranking IDENT(continuant) constraints above *VOICED STOP/V_ actually predicts a *contrast* between stops and approximants in the relevant contexts, assuming both consonant types are present, at least theoretically, in the input representation. This is problematic not only for Spanish, which has no phonological continuancy contrast in the natural class of voiced obstruents, but also cross-linguistically, as spirantization processes typically do not neutralize phonological contrasts in only a subset of positions (Katz, 2016). We return to a fuller discussion of these theoretical issues in Section 4.4 of Chapter 4.

1.6 Research questions

The following research questions aim to fill a gap in the intersection of heritage language research, theoretical and laboratory phonology, second language acquisition, and sociolinguistics. Largely, the purpose is to provide a quantitative experimental perspective that can account for the heterogeneity of the heritage speaker population, and to contribute a formal theoretical model of possible patterns of variation that makes typological predictions. The questions are as follows:

1) How do U.S. Spanish speakers of Colombian heritage produce intervocalic voiced stops (/b, d, g/)?
2) How does their pronunciation of postvocalic voiced stops vary as a function of the following variables?
    a. Phoneme
    b. Syllable stress
    c. Prosodic domain
    d. Task type
3) What social factors in a speaker's linguistic background affect individual variation in voiced stop lenition?
4) How can patterns of voiced stop lenition in Colombian heritage Spanish be modeled in a phonetically-based Optimality Theory framework?

1.7 Conclusion

In this introduction chapter I reviewed the main literature relevant to the present study, including the sociolinguistic context of the participants, the linguistic factors that make up the basis of this study, and the gap that this dissertation aims to fill in the theoretical analyses of spirantization.

The organization of the overall dissertation is as follows. Chapter 2 presents the methods of data collection and analysis. Chapter 3 examines the results of the quantitative data. Chapter 4 proposes a phonetically-based analysis of spirantization within the framework of Optimality Theory. Finally, Chapter 5 reviews the main results of the study, the implications of the findings, limitations, and future directions for analysis of the data.

CHAPTER 2: METHODS

2.1 Introduction

In light of the various studies conducted on the production of /b, d, g/ and other phonetic features that are conditioned by speech style, the methods of the experimental tasks for this study were designed to elicit both careful speech and casual speech. A recorded reading task, conversation, and a questionnaire were completed to allow for measurements of variation in the production of intervocalic /b, d, g/. Sixteen speakers participated in the tasks across two locations. Nine of the participants live in the Miami area, seven in Northern New Jersey, and as such, they are residents of the two main metro areas that constitute the largest populations of Colombians in the U.S. The following research questions motivated the experimental design of the data collection tasks.

(6) How do U.S. Spanish speakers of Colombian heritage produce intervocalic voiced stops (/b, d, g/)?

(7) How does their pronunciation of intervocalic voiced stops vary as a function of the following variables?

   a. Phoneme

   b. Syllable stress

   c. Prosodic domain

   d. Task type

The dependent variable is the categorical production as either a stop, tense approximant, or pure approximant. A full description of each category will be presented in Section 2.4. The reading task controlled for four independent variables. (i) Phoneme: bilabial (/b/) (orthographic <*v*> is excluded from analysis); coronal (/d/), dorsal (/g/); (ii) Lexical stress of the syllable in which the target token occurs: stressed or unstressed; (iii) The prosodic domain of the token in three contexts: initial at syllable level (e.g. *caballo* ‘horse’), initial in the minimal prosodic word (e.g. *la ballena* ‘the whale’), and initial in the maximal prosodic word (e.g. *es un curso básico* ‘it’s a basic course’); (iv) The type of task in which the token occurs: a reading task vs. a conversation dyad.

The remaining sections of this chapter will present information about the participants of the present study (Section 2.2), the methods of data collection, and design of the tasks and materials (Section 2.3), as well how the data will be evaluated (Section 2.4) and a description of the research hypotheses (Section 2.5).

2.2 Participants

All of the participants in the study are of Colombian heritage in either Southern Florida or Northern New Jersey, where the largest populations of Colombians reside in the U.S. (Migration Policy Institute, 2015). The motivations for focusing on this particular variety of U.S. Spanish are threefold. First, there is a need for documentation and research of U.S. Spanish varieties in their own right without comparisons to native speaker “control” groups, monolingual speakers from the country of origin, L2 speakers, or other groups that are sometimes arbitrarily compared to heritage Spanish populations of study. As Otheguy (2016) and Zentella (2016) point out, researchers often position bilingual speakers as *incomplete* or *deficient* in relation to other varieties or speakers, without considering the contexts in which the grammars exist and develop (see Chapter 1). Second, Colombian highland Spanish is a variety that tends to be more "conservative" than both coastal Colombian varieties and other "innovating" dialects. With respect to stop lenition processes, it is characterized as favoring stops in certain phonological contexts (e.g. after consonants) where other more "innovating" dialects favor lenited realizations (Harper, 2014; Lewis, 2001). Third, the Spanish of Colombian heritage speakers in the U.S. is in contact with English, which lacks a systematic process of voiced stop lenition, although phonetic weakening of English stops to continuants in informal speech has been documented (Brown, 1990: 79; Lavoie, 2001: Chapter 5; Cruttenden, 2008: 168). The present study leverages both the lower prevalence of stop lenition in Colombian Spanish relative to other varieties, and the potential for negative phonological transfer from English in the U.S. context, in order to encourage greater phonetic variation of the dependent variable categories across the contexts and conditions defined by the independent variables. In intervocalic contexts, we can expect a wider range of allophones, including more stops, than would be expected of Spanish varieties situated on the more "innovating" end of the continuum, where higher frequencies and greater degrees of stop lenition are the norm.

In order to examine the phonological effects in connection to language experience, this study recruited participants who identified as being of Colombian heritage. Since I am a member of this speech community, my familiarity with community members aided in the recruitment and afforded me speaker solidarity with the participants. Zentella (1997) describes the advantages of an in-group researcher, "membership in the ethnic group which is being studied should enable the researcher to dispense with interpreters, to be sensitive to cultural norms, and to have easier access to and more profound relationships with a larger number of community members" (7).

Participants were recruited via the snowball method with participants recommending other members of their speech community (Buchstaller and Khattab, 2013). All speakers have some proficiency of Spanish, following Valdés's (2001) definition of a heritage speaker. Speaker generation is based on the classification of three immigrant generations used in language maintenance and shift models (Fishman, 1964). The generations are classified in (8):

(8) Generations

G1: Immigrated to the U.S. from Colombia

G2: Born in U.S. to at least 1 parent born in Colombia

G3: Born in U.S. to at least 1 G2 parent

Following Amengual (2019), I classify participants as either sequential or simultaneous bilinguals based on their order of English language acquisition, with sequential speakers using only Spanish before the age of 5. This classification, along with participant age, self-identified gender, generation with age of arrival to the U.S., and place of residence, is outlined in Table 2.1.

Table 2.1. Participant demographic summary

Participant	Age	Gender	Generation (Age of arrival)	Location	Order of Acquisition
María	67	female	1 (17)	FL	Sequential
Lollipop	48	female	2	FL	Sequential
MommaKat	50	female	2	FL	Sequential
Carmen	49	female	2	FL	Sequential
Dalia	20	female	2	FL	Simultaneous
Andrea	19	female	3	FL	Simultaneous
Lola	21	female	3	FL	Simultaneous
Liliana	18	female	3	FL	Simultaneous
Sergio	24	male	3	FL	Simultaneous
Marby	57	female	1 (11)	NJ	Sequential
Janine	60	female	1 (13)	NJ	Sequential
Mariela	51	female	1 (6)	NJ	Sequential
Esperanza	19	female	2	NJ	Simultaneous
Katrina	29	female	2	NJ	Simultaneous
Maximos	18	male	2	NJ	Simultaneous
Victor	26	male	2	NJ	Simultaneous

2.3 Experimental design

The methods of the phonetic experiment come from previous studies on the production of voiced stops by both heritage and L2 Spanish populations, in particular Amengual (2019), Cabrelli Amaro (2017), and Rao (2014, 2015). The dependent variables are the categorical manner of articulation based on Rao’s (2014, 2015) classifications of stops, tense approximants, and pure approximants (see Section 2.4 for the acoustic criteria that distinguish among these phonetic categories). The independent variables are phoneme, syllable stress, prosodic domain, and task type. The two main production tasks consisted of (i) a list of test items embedded in a carrier phrase and (ii) recorded conversation in pairs. The justification for having only a reading task and a recorded conversation but no intermediate-level paragraph reading task is that Lewis (2001) found no significant difference of voiceless stop production between a word-list task and a paragraph reading task among Colombian Spanish speakers. However, he did find a significant difference between the word-list and conversational speech tasks. While Rao (2014, 2015) includes data from readings of word lists and short paragraphs as well as spontaneous interviews, Amengual (2019) and Cabrelli Amaro (2017) collect data only from a controlled reading task.

The audio was recorded with a Zoom H4nPro digital recorder at 44,100 Hz with a 16-bit depth. Each participant used a lavalier microphone clipped onto their shirt approximately 4-6 inches away from the talker’s mouth. It was important to maintain this distance consistently for all talkers in order to ensure some degree of normalization of acoustic intensity, as intensity was used as a guide in the subsequent classification of tokens into the dependent variable categories. The Zoom H4nPro allows digital audio recording on multiple tracks via two XLR/TRS microphone inputs. In the conversation dyad task, participants were recorded separately and simultaneously at a comfortable distance from one another. Separation of the participants’ recordings into two different .wav files was essential in order to minimize overlapping speech within a single track and to increase the number of useable tokens. Nearly all recordings took place in a home of one of the participants and in a quiet room with bedding or fabric to reduce background noise.

2.3.1 Reading task

The reading task was administered on a PDF slideshow presentation via iPad. Each slide presented a target word within the carrier phrase *"Diga ___ una vez."* The participants were prompted to complete the task at their own pace and told they would be provided the opportunity to pause at indicated intervals throughout the presentation and could continue again at their own pace. The list of experimental stimuli was based on the Davies *Corpus del Español* (corpusdelespanol.org), which searches text from webpages in 21 Spanish-speaking countries. The tokens come from the top 100 results of searches by part of speech (nouns, adjectives, verbs), ranked by frequency within the sub-corpus of Colombian Spanish. The tokens were selected within the parameters of an intervocalic /b, d, g/, with the following vowel /a/, a word length of 3-4 syllables, and an equal distribution of stressed and unstressed words. Examples of tokens presented in a carrier phrase for the three levels of prosodic domain are provided in (9) – (11). The full list of stimuli within the carrier phrase can be found in Appendix A.

(9) Syllable

*ca**b**allo*	*pe**d**azo*	*abo**g**ada*
‘horse’	‘piece’	‘lawyer’
*sá**b**ana*	*na**d**ador*	*obli**g**ación*
‘bed sheet’	‘swimmer’	‘obligation’

(10) PW-min

*mi **b**arrio*	*la **d**ama*	*mi **g**ato*
‘my neighborhood’	‘the lady’	‘my cat’
*la **b**allena*	*la **d**anesa*	*la **g**allina*
‘the whale’	‘the Dane’	‘the hen’

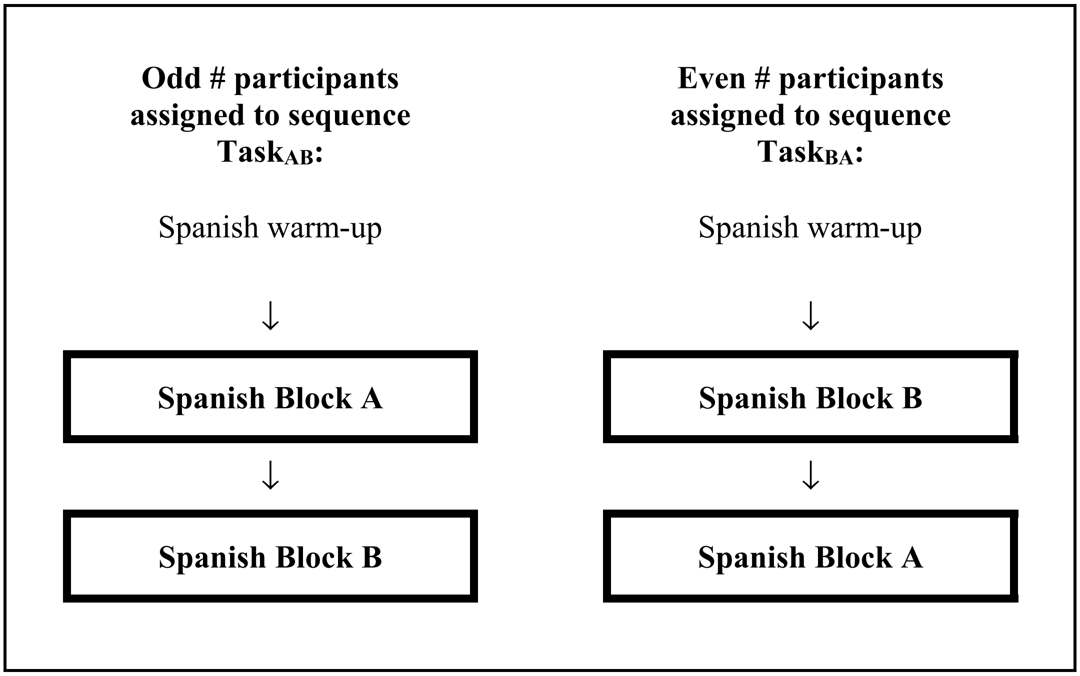
(11) PW-max

*es un curso **b**ásico*	*no veo **d**amas*	*es el mismo **g**ato*
‘it’s a basic course’	‘I don’t see ladies’	‘it’s the same cat’
*me quiero **b**ajar*	*no puedo **d**añarme*	*una buena **g**arantía*
‘I want to get down’	‘I can’t hurt myself’	‘a good guarantee’

To maximize the number of measurable tokens per participant while attempting to reduce participant fatigue, each task consisted of four repetitions of each token with no distractors, and was divided into two semi-randomized blocks, following a design similar to that used by Strycharczuck and Kohlberger (2016). After completion of the Spanish carrier phrase stimuli, participants were recorded reading items in an English carrier phrase task in two shorter blocks of stimuli to allow for an examination of their pronunciation of intervocalic voiced stops in English. An informal random spot check of this data confirms a consistent lack of lenition across participants indicating that when pronouncing these same stimuli within an English carrier phrase (e.g. "Say *la danesa* one time," "Say *abogado* one time," etc.) they do not lenite as they would in Spanish. However, a carefully controlled comparison of the two languages lies outside the scope of the present analysis and will not be reported here.

The experimental design in Figure 2.1 uses counterbalancing to control for order-of-presentation effects. Each list of target phrases was semi-randomized in Excel to produce two different list sequences, Blocks A and B, in order to avoid the immediate repetition of a single item, or long stretches of the same repeated domains. Then, for every pair of participants from the same generation and same geographic location, each person was assigned to a different sequence: Task_{AB} or Task_{BA}. The task began with a warm-up that included instructions and practice carrier phrases designed to familiarize participants with the format and procedure. To reduce the potential for fatigue, all participants were given the instructions between blocks to rest briefly for five minutes. Each task consisted of 144 total items of stimuli (3 phonemes × 2 stress × 2 items × 3 domains × 2 repetitions × 2 blocks = 144 total items). The task is organized according to the sequence of Blocks A and B, as detailed in Figure 2.1.

Figure 2.1. Counterbalanced blocks of semi-randomized experimental items



Each participant was prompted with instructions on how to complete the task and go to the next slide. The start of the task began with six warm-up examples of six randomized items (2 of each condition) within the same carrier phrase to test the audio and ensure that they understood the task. For example, the warm-up slides would appear in gray with the phrase, “*Diga* __zapato__ *una vez*.” The warm-up examples reflected similar structure to those included in the task but did not include any of the same stimuli used in the experimental items. The participants were instructed to read the sentences aloud, as they would naturally say them in Spanish.

2.3.2 Questionnaire

The questionnaire consists of four sections: demographics, language use, language proficiency, and language attitudes. The first section includes questions about age, gender, family background, education, and preferred terms for their identity. The second section reports on language use and interlocutors at different ages in the participant's life (age 0-5, elementary/middle school age, high school age, and 18+), who they use the language with, and what language they use for particular activities. The wording and organization of the third section on language proficiency comes from the Bilingual Language Profile (BLP), which uses self-reported evaluations of language proficiency and frequency in speaking, understanding, reading, and writing in each language (Birdsong et al., 2012). The complete BLP survey provides a quantitative score of language dominance, which is not calculated for the purposes of the present dissertation because only this section on language proficiency was collected. The final section on attitudes asks the participants to agree or disagree with a series of statements on the importance and difficulty of using two languages, language mixing, language maintenance, and what it means to be bilingual. The specific questions can be found in Appendix C. For the current analysis, the results from reported language use and evaluations of language proficiency will be used to understand the relationship between language experience and patterns of voiced stop lenition.

2.3.3 Conversation dyad

Participants in both speech communities were paired up with another participant that they knew and were comfortable speaking with. However, in some cases speaking Spanish was not a normal dynamic between participants despite all participants being bilingual in English and Spanish to some degree. Each participant wore a lavalier microphone in the same position as in the reading task. They were prompted to have a conversation for about 15-25 minutes on whichever topic(s) they preferred. They were also provided with an iPad with conversational questions if they wanted to have prompted questions. In only one circumstance was a conversation recorded between a participant and another non-participant (bilingual, but not Colombian). In three of the conversations, the researcher was involved in the conversation and mostly participated in asking questions of the other two participants but was not directly recorded by microphone. The tokens from the conversations come from the first 25 minutes of recording. Tokens that were inaudible were eliminated from the analysis. An example of these intervocalic segments (boldfaced) in context are provided in (12).

(12) María: *Va a ha**b**er un tiempo en que nosotros no-- ahí no se pue**d**e hacer na**d**a. Pero yo **d**i**g**o que están haciendo eso en el come**d**or--*

Lollipop: *Oh, sí en el come**d**or, no te **d**ejan XXX*

María: *No. Ahoritica no. Pongamos las clases del miércoles no van a hacer ya ahí van a ser – se lo **d**ijo a la gente i**b**a a ser en otra parte en un salón de esos que está un poco más amplio, pero hay—*

María: 'There will be a time that we [can't]—we can't do anything there. But I'm saying that they're doing this in the cafeteria.

Lollipop: Oh, yes in the cafeteria, they won't let you XXX

María: No. Not right now. We decided not to do the Wednesday classes there – they told people it would be in another area in one of those rooms that's a little bigger but there's--'

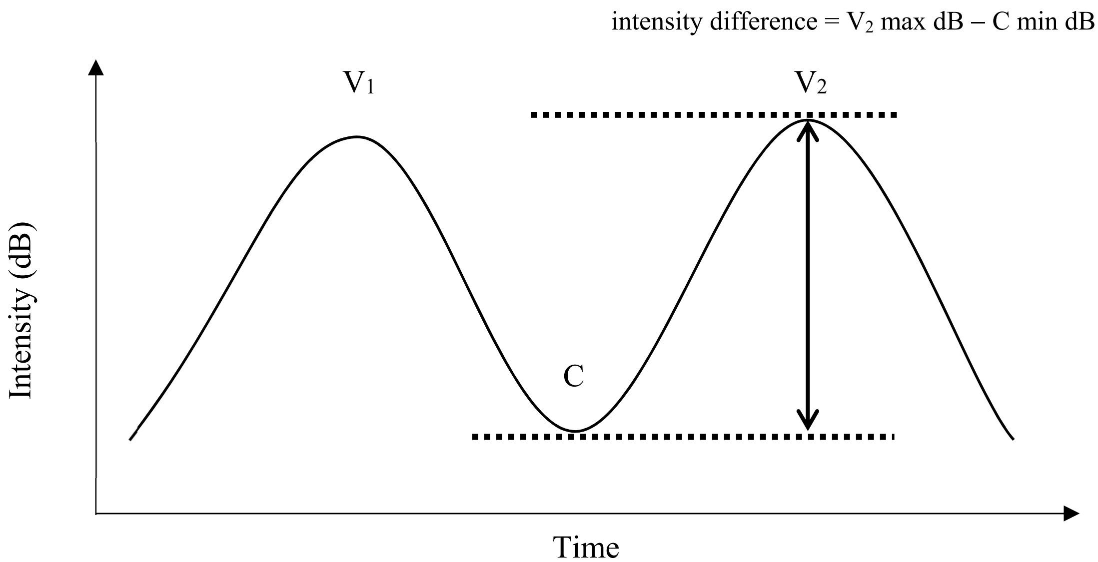
2.4 Coding

All acoustic data were annotated in Praat (Boersma & Weenink, 2021). In order to aid in segmentation, I ran the Praat script *mark pauses* to search for the pauses in between carrier phrases (Lennes, 2002). The script creates a boundary of *utterance* and *silence* within the Praat text grid.

The tokens in the conversational data were manually segmented. Tokens that occurred within the minimal prosodic word in a syllable onset were classified as Syllable (e.g. *lago* [ˈla.ɣ̞o] 'lake'). Tokens in a word-initial intervocalic position were classified as either PW-min (e.g. *me dice* [meˈ.ð̞i.se] '(s)he tells me') or PW-max (e.g. *carne guisada* [ˈkaɾ.ne.ɣ̞iˈ.sa.ð̞a] 'cooked meat') depending on the previous word's stress and assuming the projections of the prosodic word defined by Itô and Mester (2007, 2009a,b).

Following the categories presented in Rao (2014, 2015), each token in both the reading task and conversation was categorized as a pure approximant (PA), tense approximant (TA), or stop (Stop). The categorization was performed manually based on audiovisual inspection in Praat, including visual estimations of the intensity difference between the intervocalic consonant and the following vowel, as illustrated schematically in Figure 2.2. This metric subtracts the intensity measure taken at the minimum dB value during the consonant (C) from the intensity measure taken at the maximum dB value during the following vowel (V_2) (Hualde et al., 2011: 309). A larger difference in intensity indicates a tighter articulatory constriction, and conversely, a smaller difference indicates a more open constriction. While other acoustic measurements involve calculating the intensity ratio, which divides the consonant's minimum dB by the vowel's maximum dB, or calculating the abruptness of the CV intensity transition between minimum and maximum dB (Hualde et al., 2010), Parrell (2010) presents evidence based on measurements from electromagnetic mid-saggital articulatography that intensity difference is the acoustic measurement that most accurately reflects degree of articulatory constriction in /b/. Therefore, the decision to use intensity difference as a visual estimation in the phonetic categorization of tokens in this dissertation not only follows Rao's (2014, 2015) methodological precedent for heritage Spanish populations but is also grounded in the recent work on voiced stop lenition in Spanish varieties more broadly.

Figure 2.2. Intensity contour of a vowel+consonant+vowel sequence



Following the ranges of dB values used by Rao (2015: 55), tokens were categorized as a PA if the intensity difference was within 2-4 dB (Figure 2.3), as a TA if >5 dB (Figure 2.4), and as a Stop if >5 dB and a release burst is present (Figure 2.5). A Praat script, written by Francisco Torreira in 2005, was used to produce the waveform and spectrogram displays of these example tokens, which illustrate the production of /ba/ in the phrase *lo básico* ('the basics'). Intensity contours were extracted in Praat and then redrawn on top of each spectrogram. For the purposes of illustration, horizontal broken lines are added here to indicate the minimum and maximum dB values of the consonant and following vowel, respectively. The PA in Figure 2.3 shows a slight decrease in intensity during the bilabial approximant relative to that of the following vowel. The greater intensity difference in Figure 2.4 indicates that the TA has more constriction than the PA but that the articulators still do not close completely, differentiating the TA from a Stop. Finally, the Stop in Figure 2.5 shows the greatest intensity difference and degree of constriction of the three categories, with complete closure and a release burst occurring immediately before the initiation of formant transitions into the following vowel. As indicated by the vertical broken rectangle, the burst is visible, both in the lower half of the spectrogram's frequency range and in the amplitude shape of the waveform shown above.

Figure 2.3. Pure Approximant [β̞] : 2-4 dB intensity difference between V_2 maximum and C minimum

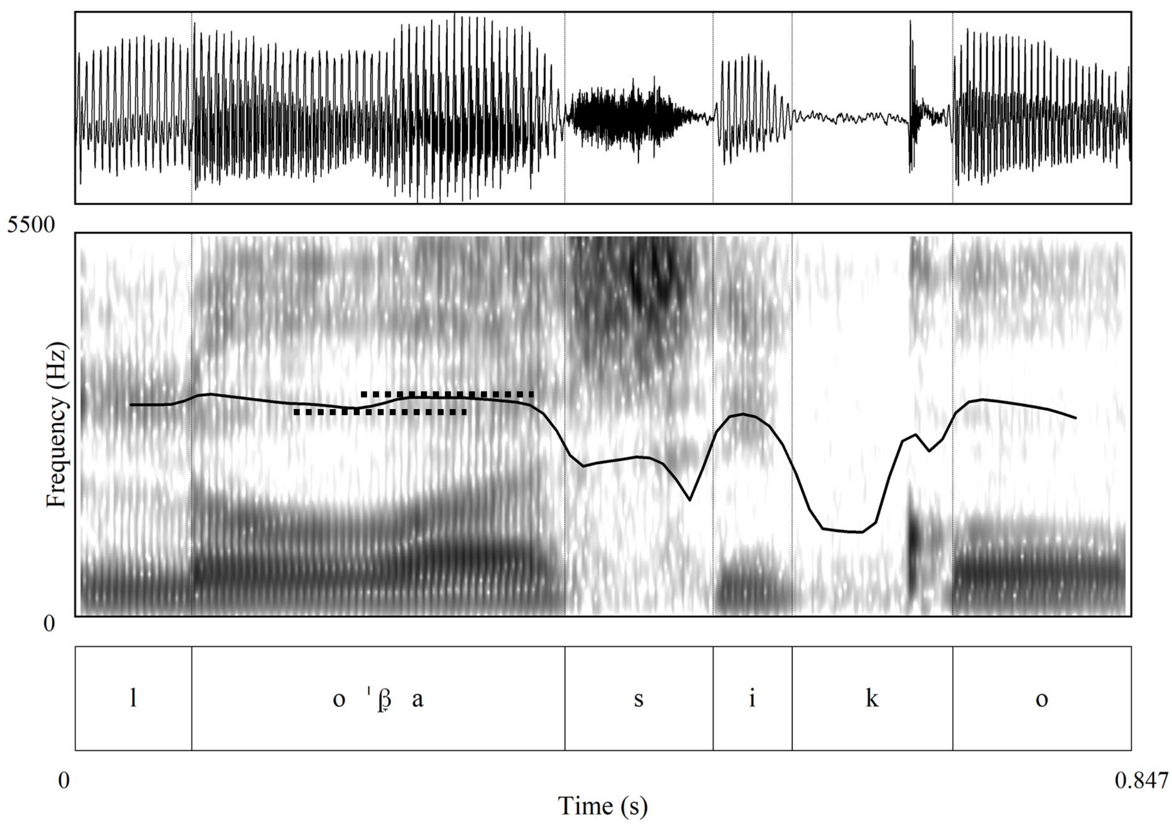


Figure 2.4. Tense Approximant [ḅ] : >5 dB intensity difference between V_2 maximum and C minimum

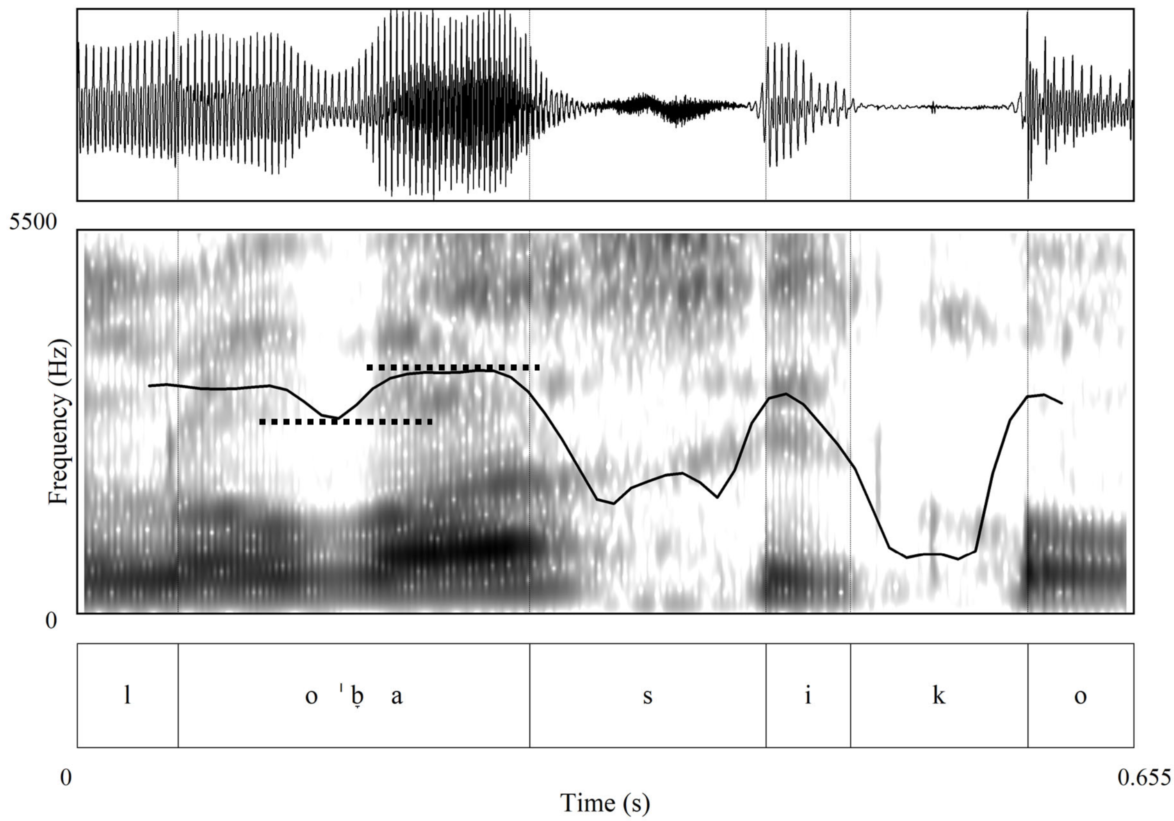
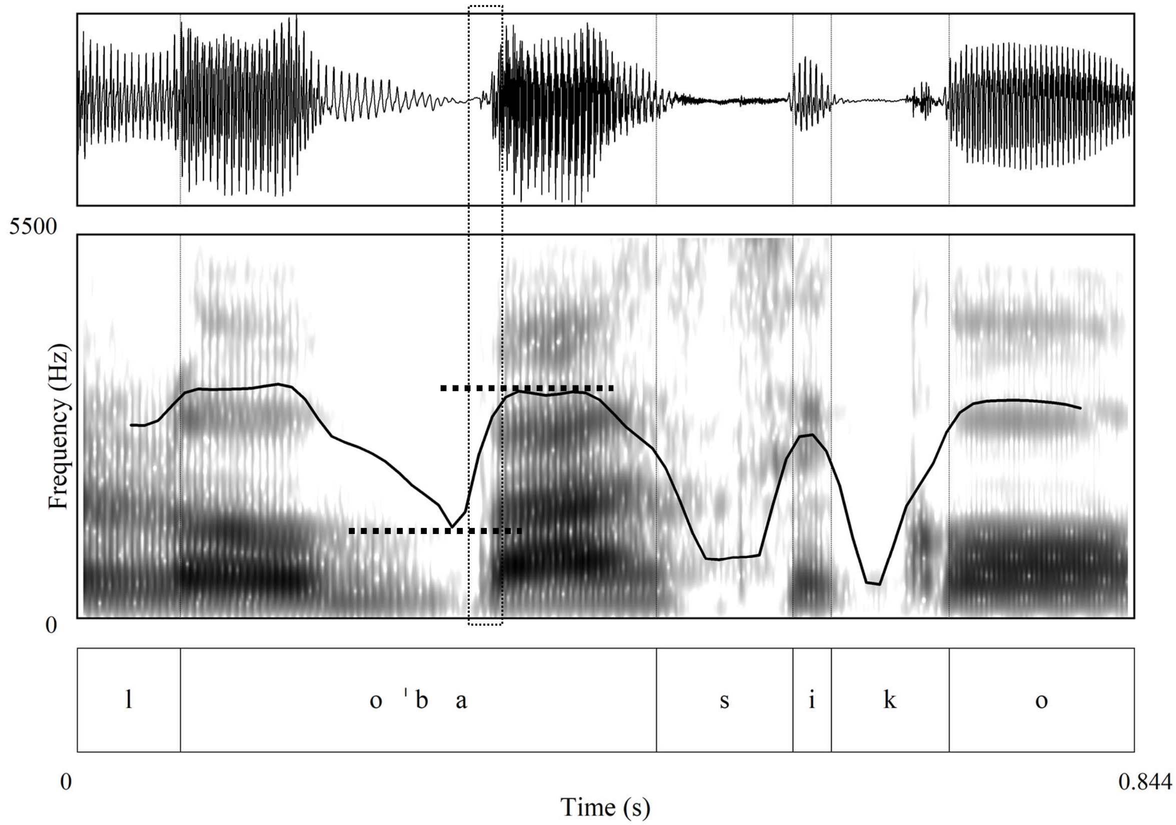


Figure 2.5. Stop [b]: >5 dB intensity difference between V_2 maximum and C minimum, and presence of stop release burst



The tokens from the reading and the conversation tasks were manually coded as one of the three dependent variable categories, rather than calculating a continuous measure of intensity difference. Therefore, quantitative measurements of intensity were taken only when needed to distinguish TAs from PAs, or TAs from Stops, as the distinction between TAs and Stops was the easiest to identify by audiovisual inspection alone. Other studies (Amengual, 2019; Cabrelli Amaro, 2017; Carrasco, 2008; Hualde et al., 2011, among others) use continuous measures of the intensity difference in their statistical analyses. For the purpose of the analysis in this dissertation, categorization of the tokens is sufficient to answer the research questions posited.

Certain tokens were eliminated from analysis in both the reading task and the conversational dyad. In the reading task, pronunciations that resulted in a change of stress or number of syllables from the targeted parameters were removed (e.g. *[mi.β̞aˈ.ri.o] vs. [miˈ.β̞a.ri̯o] *mi barrio* 'my neighborhood'). In the conversational data, tokens were not considered if the sound was inaudible or unintelligible, often due to overlapping speech between interlocutors. The preposition *de* was not included in the data set due to its high frequency. Only tokens of /b, d, g/ in an intervocalic position were analyzed, including both word-medial and word-initial contexts. Instances of word-initial /b, d, g/ after a pause or a word-final consonant were not included.

2.5 Hypotheses

Based on the previous literature on voiced stop lenition in Spanish, in this section I will outline the hypotheses for each of the independent variables of study.

2.5.1 Phoneme

Previous studies of spirantization and stop lenition have indicated that the phoneme most likely to weaken is variable by dialect. Bybee (2001) finds that the weakening and deletion of intervocalic /d/ in New Mexican Spanish is more likely in high frequency words than in low frequency words, especially in the /–ado/ suffix of the past participle of verbal forms. Using acoustic data from "innovating" Caribbean Spanish varieties that favor spirantization of intervocalic voiced stops, Ortega-Llebaria (2004) measured the RMS-amplitude ratio between the intervocalic consonant and following vowel and found evidence of a vowel effect: /g/ showed a greater degree of constriction in the context between low vowels but higher degrees of lenition between high vowels. There were no significant effects for /b/ (/d/ was not analyzed).

Colantoni and Marinescu (2010) carried out an acoustic analysis of intervocalic voiceless and voiced stops in Argentine Spanish varieties based on duration, percentage of voicing, and CV intensity ratio. For /p, t, k/ they found very little voicing and no significant differences in duration or intensity ratio. For voiced stops, however, intensity was found to differ significantly by phoneme in the direction /d/ > /b/ > /g/, and /d/ was found to be shorter and to delete more often than /b/ and /g/.

Using continuous measurements from speakers across a range of different Spanish dialects and phonological contexts, Eddington (2011) found lower intensity differences (i.e. more lenited pronunciations) for /b/ and /d/ in word-internal intervocalic positions than in word-initial intervocalic positions, while /g/ displayed no such sensitivity to word boundary.

Carrasco et al. (2012) compared Costa Rican Spanish with Madrid Spanish and found a crucial difference between the two varieties with respect to the lenition of /b, d, g/ in various left-hand segmental contexts, as indicated by mean intensity ratio. In Madrid Spanish, the researchers observed a continuum of constriction degrees conditioned by the preceding segment, with no clear separation between postvocalic and other left-hand contexts. In Costa Rican Spanish, /g/ showed less constriction than /b/ and /d/ in postconsonantal position but greater constriction than /b/ and /d/ in postvocalic position, after the low vowel /a/. Carrasco et al. (2012) "surmise that this may have to do with the fact that /g/ can shift its point of articulation to coarticulate with vowels" (169), given that vowels and dorsal stops are both articulations that involve the tongue body.

Recent acoustic studies of more innovative lenition varieties contribute to the overall mixed findings with respect to weakening by individual phoneme. Focusing in particular on the approximant allophones of the three voiced stops across a range of different phonological contexts, Figueroa (2016) found that Chilean Spanish

> "can be characterized as a dialect with a particularly high degree of lenited and elided variants. Although this trend is true for all three phonological categories, it finds its extreme in /d/, for which elision was the most frequent variant, followed by /b/, in which highly lenited variants predominated, and then by /g/, in which open approximants were more frequent" (115).

Finally, Canary Island Spanish is known for its voicing of intervocalic voiceless stops and for its advanced stages of spirantization and deletion of the voiced stops. Broś et al. (2021) examined contextual lenition patterns in the variety spoken on Gran Canaria. For voiceless stops across all contexts, they found that /t/ is the most likely to weaken, followed by /p/ then /k/, while for the voiced stops, /d/ is more likely to weaken than either /b/ or /g/ (Broś et al., 2021: 24-25).

Based on these studies of different Spanish varieties, it seems clear that dorsal voiced stops have a greater potential to pattern differently than bilabial and coronal voiced stops, although /d/ tends more towards deletion in the most innovative dialects. In postvocalic contexts, the different behavior of /g/ typically manifests as a greater resistance to lenition relative to the non-dorsal stops.

As for heritage Spanish in particular, Rao (2015) found that heritage speakers in the Upper Midwestern U.S. lenited to the category of PA in intervocalic positions more frequently for /d/ and /g/ than for /b/. (Rao, 2014 examined only on the bilabial stop.) Based on continuous measures of intensity difference, Amengual (2019) found that sequential and simultaneous Spanish bilinguals, and second language learners, in northern California showed significant differences in the degree of spirantization for /b, d, g/. Although he did not test for differences by individual phoneme, the descriptive data show a greater range of intensity difference values, encompassing more stop-like realizations, for /g/ than for either /b/ or /d/ in the simultaneous but not the sequential bilingual group (Amengual, 2019: 11). Finally, in a recent study of intervocalic voiced stop lenition by heritage Spanish students at a western U.S. university, adopting Rao's (2015) dependent variable categories, Blair and Lease (2021) found that /b/ and /g/ are most frequently pronounced as TAs, while /d/ is most frequently a PA. The least frequent realization of the dorsal voiced stop is as a PA.

In light of the disparate findings from these studies, we would expect the distribution of PA, TA, and Stop allophones of /g/ to differ in some way from that of /b/ and /d/ in the results of the experiment with Spanish speakers of Colombian heritage described in Section 2.3, although we make no specific predictions about the directionality and magnitude of the difference.

2.5.2 Stress

Lexical stress is known to be a factor conditioning the lenition of voiced stops (Broś et al., 2021; Carrasco, 2008; Carrasco et al., 2012; Cole et al., 1999; Eddington, 2011; Hualde et al., 2011; Ortega-Llebaria, 2004). When the segment is in the onset of a stressed syllable, there is a greater degree of constriction in its articulation compared to the onset of an unstressed syllable. That is, weaker realizations are favored in unstressed syllables, while stronger realizations are favored in stressed syllables. Using the same dependent variables as the present study, Rao (2015) found significantly higher rates of PAs in unstressed syllable conditions and significantly more Stops in stressed syllables. In Rao's earlier (2014) study, focusing only on the phoneme /b/, TAs also show a significantly greater frequency in stressed than unstressed syllables. Therefore, for the Spanish speakers of Colombian heritage in the present study, we would expect to find fewer PAs in stressed syllables than in unstressed, and conversely, fewer Stops in unstressed syllables than in stressed. We make no specific predictions for the intermediate TA category.

2.5.3 Prosodic domain

When a voiced obstruent occurs in the syllable onset position within the word in an intervocalic context, lenition is the expected outcome in Spanish. In word initial position, however, stops are obligatory after a pause but alternate with approximants after a word that ends in a vowel. Most studies of intervocalic spirantization distinguish between word-medial and word-initial positions, where the latter is explicitly defined as excluding any intervening pause (Broś et al., 2021; Carrasco, 2008; Carrasco et al., 2012; Eddington, 2011; Rao, 2015). These studies found that the position of the intervocalic segment as word-internal or word-initial was an important factor in understanding spirantization, with lenition more likely to occur in word-medial than word-initial position.[3] Rao (2015) found significantly higher rates of PAs in word-medial position and Stops in word-initial position among heritage speakers. Cabrelli Amaro (2017) expanded the operational definition of word position to encompass a third category, by distinguishing between minimal and maximal projections of the prosodic word (Itô and Mester, 2007; see also 2009a,b). Using continuous measurements of intensity and data from university-level second language

[3] For Gran Canaria Spanish, Broś et al. (2021: 22) found a statistically significant difference between word-initial and word-medial contexts for both intensity and segmental duration. However, duration patterned in an unexpected direction, i.e. longer medial stops than initial ones, whereas medial stops did conform to the prediction that intensity (and aperture) should be greater than in word-initial position.

learners of Spanish, Cabrelli Amaro confirms Zampini's (1997, 1998) hypothesis that spirantization should be acquired earlier in smaller prosodic domains. However, Cabrelli Amaro's intermediate and advanced learners did not show statistically significant differences in intensity between the minimal and maximal prosodic word contexts, which suggests that only two domains—the syllable and the prosodic word—mediate the acquisition of spirantization in L2 Spanish. Data from a control group of speakers of Cuban Spanish, an "innovating" variety on the spirantization continuum, revealed a tendency towards more stop-like pronunciations at higher boundaries in the direction of syllable < minimal prosodic word < maximal prosodic word, although the differences turned out to be statistically insignificant (Cabrelli Amaro 2017: 252). A reasonable hypothesis is that weaker realizations are favored in the initial position of smaller prosodic domains, while stronger realizations are favored in larger domains. Therefore, in our experiment for Colombian heritage Spanish, we would expect to observe an asymmetry in allophone frequency across the three prosodic domains in (9) – (11), with more PAs at the syllable level than at the prosodic word levels and, conversely, more Stops at the prosodic word levels than at the syllable level.

2.5.4 Task type

The intention of the task type variable is that the reading task will elicit careful speech, while the conversation dyad will encourage more naturalistic, casual speech. The benefit of the reading task is that there is much more control to stratify the stimuli according to the independent variables of analysis. The drawback of this type of controlled task is that it may not reflect the way a speaker would produce the same segments in everyday use. The intent of the recorded conversation dyad is to approximate a more natural context that invites casual speech. This type of task, however, has its own shortcomings. First, there is the observer's paradox; while the speech may be more casual and naturalistic than in careful style, the presence of the recording equipment will no doubt influence the speakers to some extent, potentially eliciting data that does not reflect their everyday interactions. Second, the task itself of conversing with someone in Spanish may not reflect the normal language practices of the two interlocutors. That is, while both participants could speak Spanish, this may not be the language that they normally use to communicate with each other.

The distinction between careful and casual speech is known to influence the pronunciation of voiced stops, but the nature of the influence is controversial. In a foundational study on the generative phonology of Mexico City Spanish, Harris (1969) describes variation in the spirantization of phrase-medial (i.e. non-postpausal) word-initial voiced stops as a function of speech style. "In word-initial position *b, d, g* occur both as [b, d, g] and as [β, ð, ɣ]; for example, *Beatriz babea* 'Beatriz slobbers', may be pronounced [b]*eatriz* [b]*a*[β]*ea* or [b]*eatriz* [β]*a*[β]*ea.* The former is the more careful pronunciation, while the latter is more casual" (38). Cressey (1978: 71) maintains that stops occur in a slow speech style in all environments, regardless of the preceding phonological context. However, the appearance of syllable-initial voiced stop allophones can be explained by the artificial introduction of pauses between syllables during slow and highly emphatic speech. Martínez-Gil (2020) argues that spirantization "does take place in slow-tempo or deliberate styles in *natural* connected speech," further concluding that "speech tempo is not a preeminent factor in the stop ~ spirant allophonic distribution of voiced obstruents in Spanish" (47). Nevertheless, experimental studies on voiced stop lenition do reveal task effects. Including the variable of task type has shown significant differences in previous studies with conversation, picture description, and spontaneous speech recorded for casual speech data collection (Carrasco, 2008; Carrasco et al., 2012; Figueroa, 2016; Rao, 2014, 2015). Therefore, in our Colombian heritage Spanish data, we would expect the weakening of voiced stops to PAs to be more likely in conversational speech while speaking spontaneously than in careful speech while reading test stimuli within a carrier phrase. Conversely, we would expect more Stops in read speech than in the conversational dyads. We make no specific predictions for TAs.

2.5.5 Summary

A summary of the research hypotheses for each of the independent variables is given in Table 2.2.

Table 2.2. Summary of research hypotheses for U.S. Spanish of Colombian heritage

Phoneme	The distribution of PA, TA, and Stop allophones of dorsal /g/ will differ in some way from that of bilabial /b/ and coronal /d/.
Stress	PAs will be less frequent in stressed than unstressed syllables, and conversely, Stops will be less frequent in unstressed than stressed syllables.
Prosodic domain	PAs will be more frequent at the syllable level than the prosodic word levels, and conversely, Stops will be more frequent at the prosodic word levels than the syllable level.
Task type	PAs will be more frequent in conversational than careful speech, and conversely, Stops will be more frequent in careful than conversational speech.

2.6 Conclusion

In this chapter I posited the main research questions of the dissertation related to the data collection, identified the variables of study, and gave an overview of the participants' basic demographic information. Next, I outlined the methods of experimental design, data collection, and analysis. Finally, I motivated the hypotheses of the research questions within the context of relevant studies in the literature. In the next chapter, I will present the experimental results and provide a detailed statistical analysis of both the reading and conversation task data.

CHAPTER 3: RESULTS

3.1 Introduction

The present chapter examines in depth the results of the data collected from the reading and conversation tasks as detailed in the previous chapter. Section 3.2 begins with a presentation of the quantitative results of the generalized linear mixed-effects regression models for each independent variable, as well as the significant interactions between variables. Next, Section 3.3 compares these results to previous studies in order to make general conclusions about the variation of /b, d, g/ production among heritage speakers. Finally, Section 3.5 examines a few representative case studies, based on qualitative data from the background questionnaires of several participants whose patterns differ from those of the majority of participants in the study. Section 3.6 concludes.

3.2 Overview of the quantitative data

This section will present the quantitative data from both the reading and conversation tasks. All intervocalic realizations in the data set were categorized as either a pure approximant (PA), tense approximant (TA), or Stop according to their intensity difference relative to the following vowel, as detailed in the previous chapter. Across these two tasks, the participants produced a total of 4,008 tokens of intervocalic /b, d, g/. 2,101 PAs, 1,114 TAs, and 793 Stops were realized throughout the data set. Table 3.1 provides the total number of tokens of each independent variable and the corresponding frequencies of each categorical representation of the dependent variable.

Table 3.1 Summary of token distribution

Variable	Context	Tokens	PA	TA	Stop
Phoneme	/b/	1217	59.41%	28.18%	12.41%
	/d/	1679	68.31%	15.49%	16.20%
	/g/	1112	20.77%	45.95%	33.27%
Syllable Stress	Stressed	1862	43.77%	32.81%	23.42%
	Unstressed	2146	59.93%	23.44%	16.64%
Prosodic Domain	Syllable	2010	65.87%	24.98%	9.15%
	PW-min	1129	42.43%	32.42%	25.16%
	PW-max	869	34.29%	28.31%	37.40%
Task	Reading	2281	32.70%	36.34%	30.95%
	Conversation	1727	78.46%	16.50%	5.04%

The distribution of the phoneme /b/ favors the PA production at 59.41%, followed by TAs at 28.18%, and Stops at 12.41%. We see an even greater frequency of /d/ produced as a PA at 68.31%, and more evenly distributed realizations of TAs and Stops at 15.49% and 16.20%, respectively. Finally, /g/ is realized more frequently as a TA at 45.95%, followed by Stops at 33.27% and PAs at 20.77%.

For the syllable stress variable, stressed tokens slightly favor PAs at 43.77%, while TAs make up 32.81%, and Stops 23.42%. Unstressed tokens are more common and favor the PA production at 59.93% vs. 23.44% for TAs and 16.64% for Stops.

Of the three prosodic domains, syllable-initial within the minimal prosodic word presents the greatest number of tokens and most favors the PA production with 65.87%, while TAs make up 24.98%, and Stops only 9.15%. In the initial position of the minimal prosodic word, PAs consist of 42.43% of the total tokens representing this domain, TAs are 32.42%, and Stops 25.16%. The maximal prosodic word domain contains the fewest tokens and has a more even distribution across each realization, with 34.29% PAs, 28.31% TAs, and 37.40% Stops.

For the two task types, the distribution is rather evenly distributed across the reading task with 32.7% PAs, 36.34% TAs, and 30.95% Stops. The conversation task has fewer tokens than the reading task and shows a distinct shift in distribution, with 78.46% PAs, 16.5% TAs, and only 5.04% Stops.

Table 3.2 presents the distribution of tokens by participant. The uneven distribution is due to individual variability in the production of tokens in the conversations and to the elimination of some tokens from the reading task (see the criteria detailed in Section 2.4 of Chapter 2). Since the conversation task was semi-guided, and there was no prohibition against code-switching to English, participants varied in the overall amount of Spanish they used, as well as in the number of intervocalic /b, d, g/ tokens they realized. Another possible source of variation was overall speech rate. Impressionistically, participants who appeared to talk at a higher rate of speech ended up producing more words overall.

Table 3.2 Distribution of tokens by participant across dependent variable categories

Participant	Location	Tokens	PA	TA	Stop
María	FL	344	54.07%	29.36%	16.57%
Lollipop	FL	332	63.86%	29.52%	6.63%
MommaKat	FL	238	51.68%	42.02%	6.30%
Carmen	FL	318	57.23%	25.16%	17.61%
Dalia	FL	301	65.78%	24.25%	9.97%
Andrea	FL	228	71.93%	10.53%	17.54%
Lola	FL	147	25.85%	61.90%	12.24%
Liliana	FL	143	0.70%	34.97%	64.34%
Sergio	FL	232	73.28%	14.22%	12.50%
Marby	NJ	310	47.74%	18.06%	34.19%
Janine	NJ	409	50.37%	29.10%	20.54%
Mariela	NJ	232	56.03%	27.59%	16.38%
Esperanza	NJ	185	59.46%	35.68%	4.86%
Katrina	NJ	225	48.00%	34.22%	17.78%
Maximos	NJ	164	10.37%	18.90%	70.73%
Victor	NJ	200	54.00%	25.50%	20.50%

Most of the participants produced more PAs, with TAs the second most frequent, followed by Stops. In two cases, for Andrea and Marby, PAs are the most frequent followed by Stops, then TAs. Two of the participants, Liliana and Maximos, produced mainly Stops. Only one participant, Lola, had more TAs than the other two realizations. These three participants also make up the lowest number of token realizations overall, meaning that they produced fewer tokens in the conversation task compared to the other participants. In Section 3.5, I will look more into the details of these participants in relation to their /b, d, g/ production and their linguistic background.

Due to individual variability, particularly with the distribution of tokens in the conversation task, there is an imbalance of each dependent variable category. In particular, there are fewer Stops in both tasks, but the disproportion is more conspicuous in the conversation task. Table 3.3 shows the descriptive statistics for each task type. The means indicate the average number of each dependent variable category observed per participant. (See Section 3.5 for more discussion of individual participant variation across tasks.)

Table 3.3 Descriptive statistics for task type

Task		**PA**	**TA**	**Stop**
Reading	n	746	829	706
	Mean	46.625	51.8125	44.125
	Standard Error	7.39418409	4.84872728	7.41050774
	Standard Deviation	29.5767364	19.3949091	29.642031
	Sample Variance	874.783333	376.1625	878.65
Conversation	n	1355	285	87
	Mean	84.6875	17.8125	5.4375
	Standard Error	15.3418596	3.79277685	1.4170649
	Standard Deviation	61.3674384	15.1711074	5.66825958
	Sample Variance	3765.9625	230.1625	32.1291667

The low rate of Stops throughout the data set leads to convergence errors while running the Stop model for main effects, presented in Section 3.2.1. The individual variability in token production in the conversation task also leads to issues evaluating the results for participants with fewer tokens.

3.2.1 Main effects

A series of generalized linear mixed-effects regression models, using the *glmer* function within the package *lme4* (Bates et al., 2015), were run for each of the dependent variables, including a random intercept for participant (R Studio). Each model of PA, TA, and Stop had fixed effects for the factorial combinations of phoneme, prosodic domain, stress, and task, as presented in Table 3.4. Here and throughout this chapter, statistically significant differences (at alpha level .05) are indicated by an asterisk.

The summary of main effects demonstrates that nearly all the independent variables, with the exception of /b/ vs. /d/, have a statistically significant result for the PA model. That is, a PA is more likely to be produced when the phoneme is a bilabial /b/ or coronal /d/, and less likely when a dorsal /g/. For prosodic domain, participants are more likely to produce PAs in both the PW-min and syllable contexts than in the PW-max context. Furthermore, the distinction between PW-min and syllable is also significant. Stress and task follow suit as significant within this model with PAs more likely in unstressed syllables and in the conversation task.

The TA model has fewer statistically significant results across the independent variables. As in the PA model, there is a significant difference in the frequency of TAs between /b/ and /g/ and between /d/ and /g/, but not between /b/ and /d/. Likewise, the stress of the word also has a significant effect favoring the TA outcome. All other variables are not statistically significant. The mixed model for Stops has no statistically significant results for any of the independent variables. These findings suggest that no context favors the Stop over the other two realizations of PA or TA as a main effect.

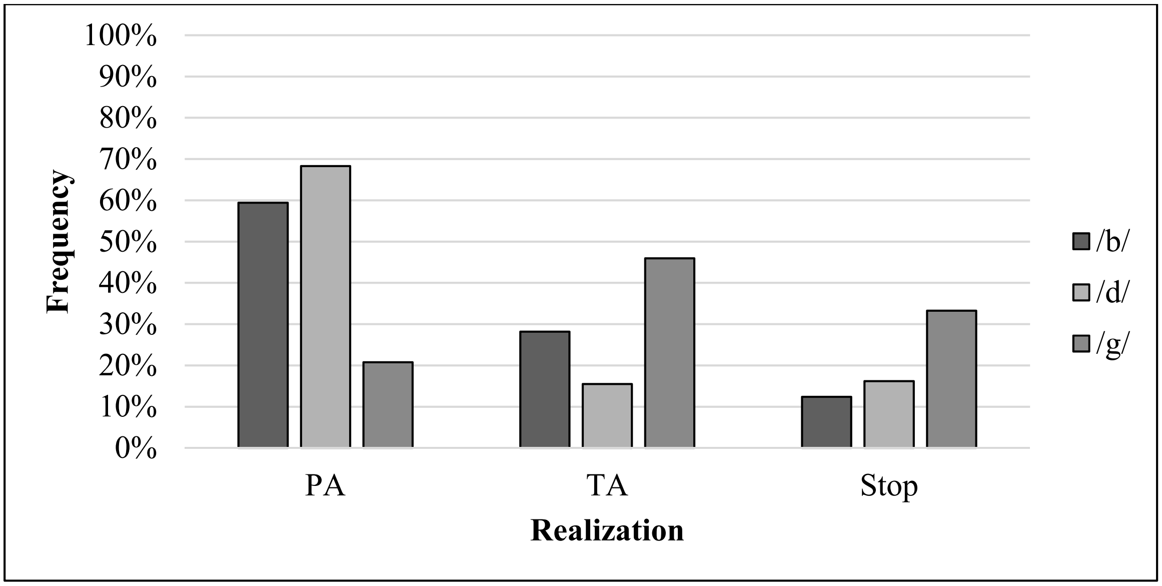
The figures in the remainder of this section illustrate the effects of each variable based on Table 3.4. The frequencies of each category of production (PA, TA, Stop) are shown for each independent variable (phoneme, prosodic domain, stress, task).

Figure 3.1 displays the frequency of manner category for each of the voiced stops by phoneme. There is no significant difference between /b/ and /d/ regarding the preference for PAs, but there is a significant difference between each phoneme and /g/, which is much less likely to be articulated as a PA. The inverse is true in the case of the TA, in which there is no significant difference between /b/ and /d/ again, but each is significantly less likely to favor TAs compared to /g/. There is no significant difference among phonemes for Stop production. Overall, Stops are less frequent across the data set (n=793) compared to PA (n=2101) and TA (n=1114) which could explain the lack of statistical significance for main effects. However, the frequency of each phoneme trends towards the expected direction with more Stop production for the dorsal phoneme /g/, which consistently behaves differently from the coronal and dorsal phonemes in the PA and TA models.

Table 3.4 Main effects

Model	Effect	Standard Error	p
PA	/b/ vs. /d/	0.143	0.1125
	/b/ vs. /g/	0.530	<.0001*
	/d/ vs. /g/	0.518	<.0001*
	PW-max vs. PW-min	0.530	0.0230*
	PW-max vs. Syllable	0.517	0.0009*
	PW-min vs. Syllable	0.138	0.0019*
	Stress	0.341	0.0005*
	Task	0.355	<.0001*
TA	/b/ vs. /d/	1.559	0.5015
	/b/ vs. /g/	0.663	0.0028*
	/d/ vs. /g/	1.399	0.0136*
	PW-max vs. PW-min	1.402	0.2325
	PW-max vs. Syllable	0.653	0.1455
	PW-min vs. Syllable	1.552	0.7729
	Stress	0.938	0.0363*
	Task	1.28	0.5671
Stop	/b/ vs. /d/	137	0.9998
	/b/ vs. /g/	642	1.0000
	/d/ vs. /g/	627	1.0000
	PW-max vs. PW-min	640	1.0000
	PW-max vs. Syllable	629	1.0000
	PW-min vs. Syllable	137	1.0000
	Stress	428	0.9997
	Task	428	0.9904

Figure 3.1 Phoneme effects



The results for syllable Stress appear in Figure 3.2. The PA manner category is observed at a higher rate in unstressed syllables than in stressed ones. Inversely, TAs appear more often in stressed syllables. The difference in allophone frequency between stressed and unstressed syllables is statistically significant for both PAs and TAs. However, the difference is not statistically significant for Stops, even though Stops are more common in stressed syllables.

Figure 3.2 Stress effects

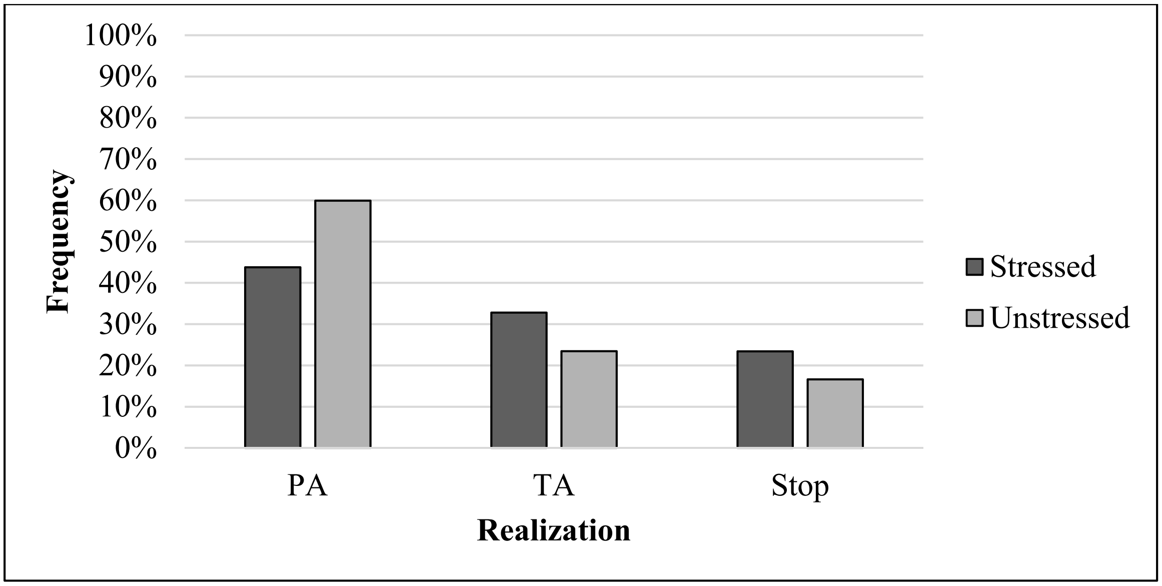
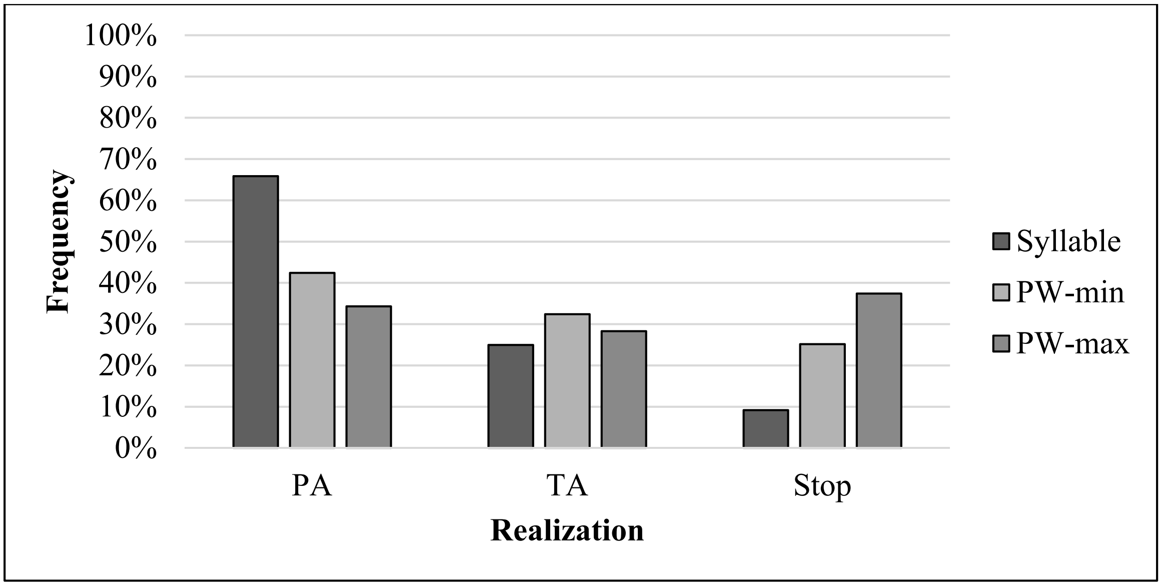


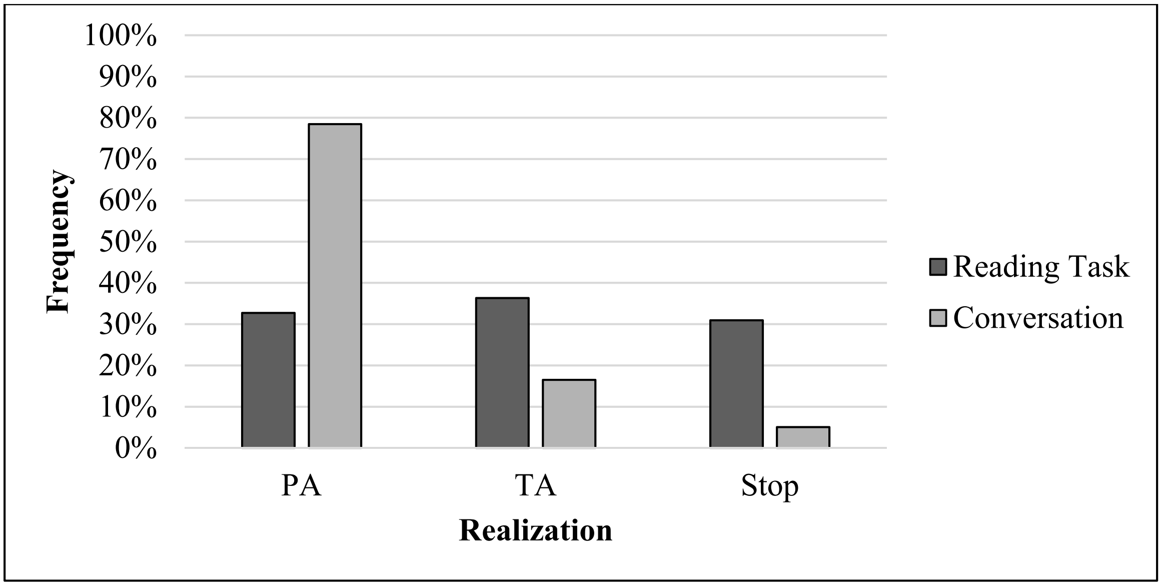
Figure 3.3 shows the effects of prosodic domain. With respect to the PA category, there is a decrease in frequency as the preceding boundary becomes higher in the prosodic hierarchy, in the following direction: syllable > PW-min > PW-max. Pair-wise comparisons reveal significant differences among each of the three contexts, but only for PAs. There is no main effect on either TA or Stop frequency, as the differences among prosodic domains are not statistically significant. Interestingly, however, the trend observed for Stops is in the opposite direction to that observed for PAs. There is a decrease in the frequency of intervocalic Stops as the preceding boundary becomes *lower* in the prosodic hierarchy: PW-max > PW-min > syllable. The TA manner category is intermediate between the significant differences observed for PAs and the statistically insignificant differences for Stops, in the sense that prosodic domains do not systematically skew TA frequency differences in one direction or another.

Figure 3.3 Prosodic domain effects



Finally, Figure 3.4 presents the frequency counts for each manner category as a function of task type. The only difference to reach statistical significance is that exhibited by PAs, which are more common throughout the conversation task. There is no significant task effect for either of the TA or Stop categories. Both tend to be less frequent in the conversation task than the reading task, a tendency which runs opposite to pattern observed for PAs.

Figure 3.4 Task effects



3.2.2 PA model interactions

Beyond individual variable effects, interactions were examined by running a series of models testing all possible pairs of each independent variable. The first model tests the interactions for PAs. Only those that have a significant result are outlined in Table 3.5.

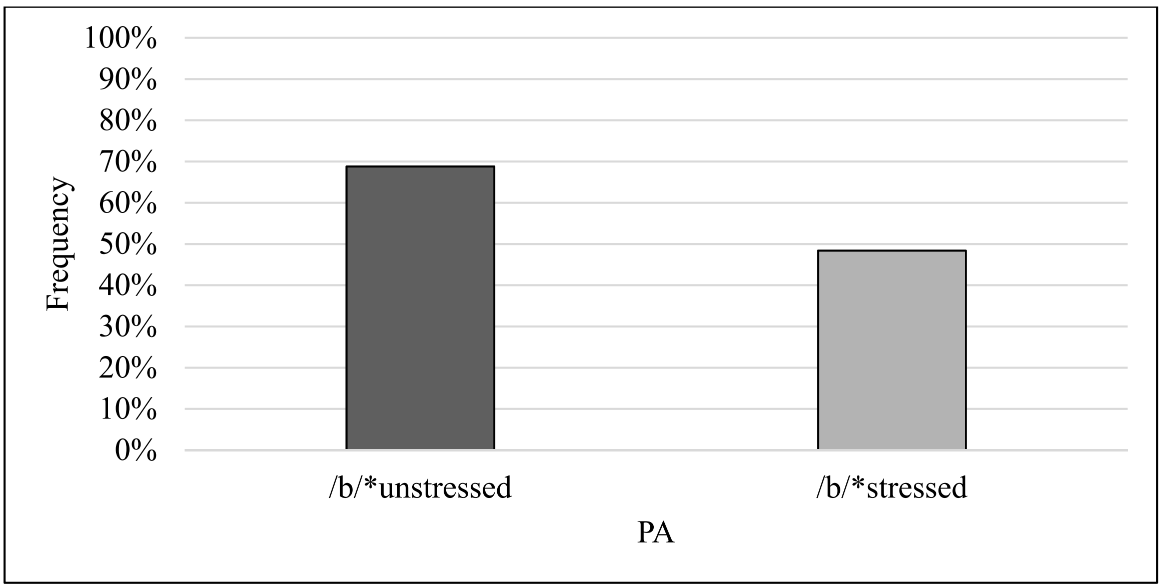
There are numerous significant effects for this model, much more so than for the other two models, which will be detailed in the next few subsections. At least one interaction between pairs of independent variables has a significant result. The following figures in this section will illustrate the interactions that are summarized throughout this table.

Table 3.5 PA model significant interactions

Interaction	Standard Error	p
/b/*Stressed	0.240	0.0203*
/b/*PW-max vs. Syllable	0.222	0.0029*
/b/*PW-min vs. Syllable	0.303	0.0179*
/d/*PW-max vs. Syllable	0.182	<.0001*
/d/*PW-min vs. Syllable	0.189	0.0014*
/b/*Conversation	0.244	<.0001*
/d/*Conversation	0.164	<.0001*
Stressed*/b/ vs. /g/	0.995	0.0013*
Stressed*/d/ vs. /g/	0.979	0.0001*
Unstressed*/b/ vs. /g/	0.301	<.0001*
Unstressed*/d/ vs. /g/	0.277	<.0001*
Stressed*PW-min vs. Syllable	0.206	0.0010*
Unstressed*PW-max vs. PW-min	0.308	0.0371*
Unstressed*PW-max vs. Syllable	0.278	0.0028*
Unstressed*Conversation	0.218	<.0001*
PW-max*/b/ vs. /g/	1.536	0.0198*
PW-max*/d/ vs. /g/	1.528	0.0205*
PW-min*/b/ vs. /g/	0.330	0.0137*
PW-min*/d/ vs. /g/	0.226	<.0001*
Syllable*/b/ vs. /g/	0.164	<.0001*
Syllable*/d/ vs. /g/	0.171	<.0001*
PW-min*Stressed	0.241	0.0001*
Syllable*Stressed	0.133	0.0291*
PW-min*Conversation	0.246	<.0001*
Syllable*Conversation	0.138	<.0001*

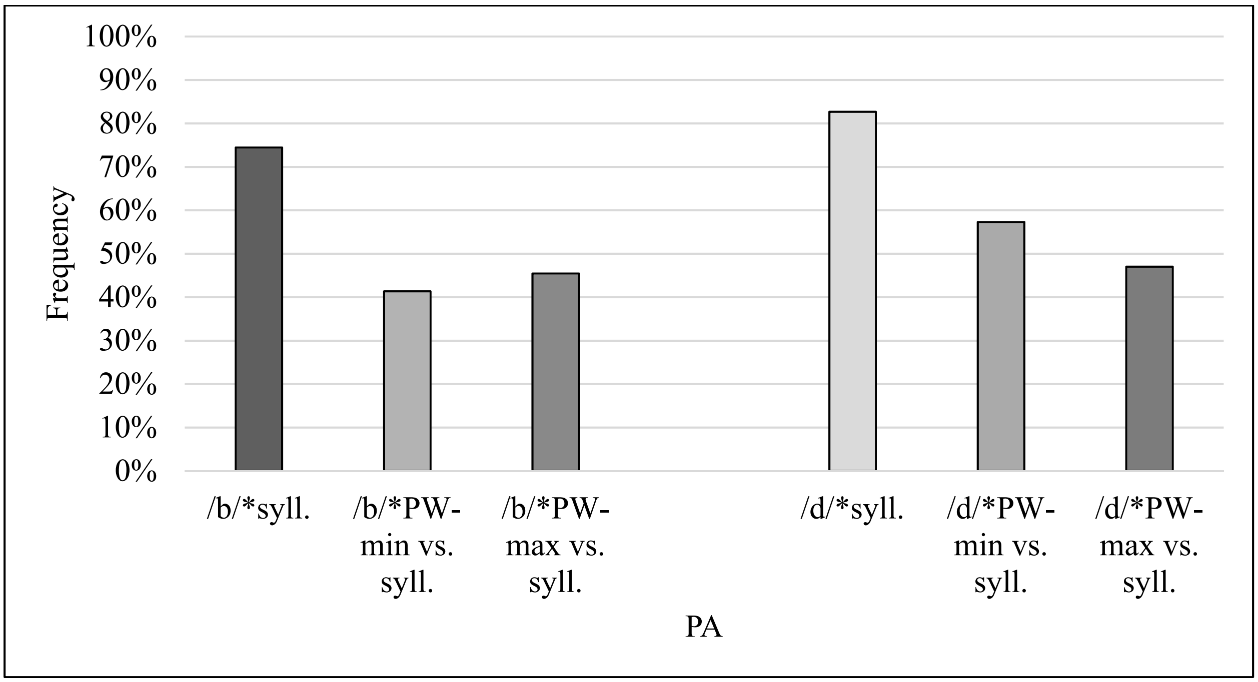
There is only one significant interaction between phoneme and stress. Figure 3.5 shows the rate of /b/ produced as a PA in unstressed syllables (69%) on the left, and the rate of /b/ articulated as a PA within stressed syllables (48%) on the right. The relationship between phoneme and stress is such that intervocalic /b/ is less likely to be realized as a PA in the onset of a stressed syllable. Neither of the other two phonemes shows a significant interaction with syllable stress for PAs.

Figure 3.5 PA model: phoneme and stress interactions



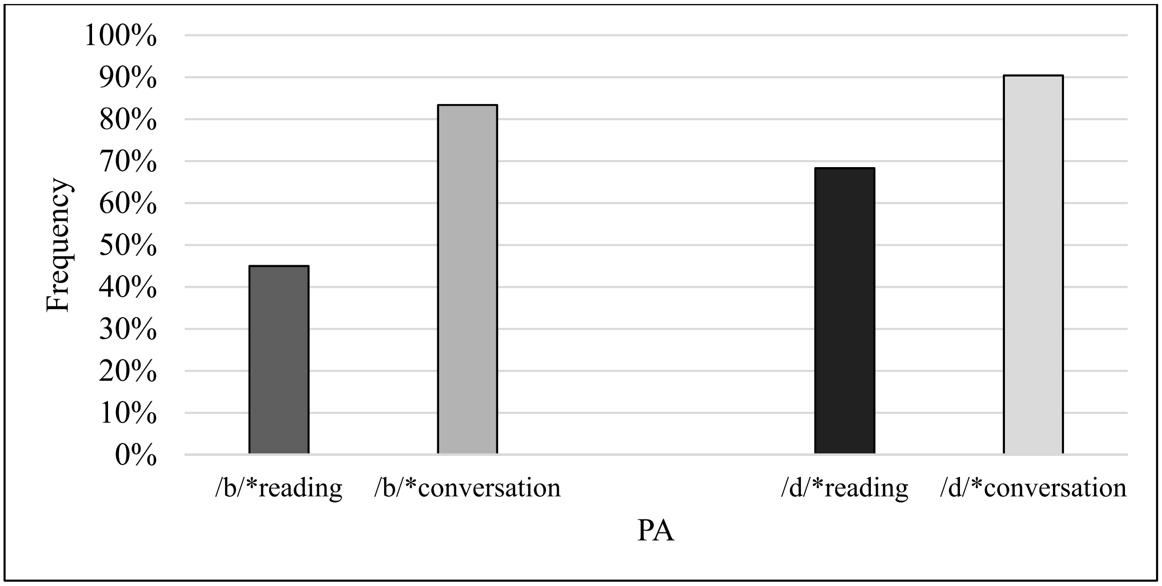
There are four significant interactions between phoneme and prosodic domain variables. Each half of Figure 3.6 shows the rate of /b/ (74%) and /d/ (83%), respectively, produced as PAs in the syllable domain on the left, and on the right, higher prosodic domains in which the frequency count diverges significantly. For /b/, there is a significant interaction involving both PW-min and PW-max. A PA is less likely to occur when /b/ is the context of the PW-min domain (41%) and PW-max domain (45%) compared to the syllable domain. In a parallel manner, /d/ interacts significantly with the same two domains, which are less likely to solicit a PA realization in the context of the PW-min (57%) and the PW-max (47%) compared to when it occurs in the syllable domain. By contrast, the phoneme /g/ does not show the same interactions with prosodic domain.

Figure 3.6 PA model: phoneme and prosodic domain interactions



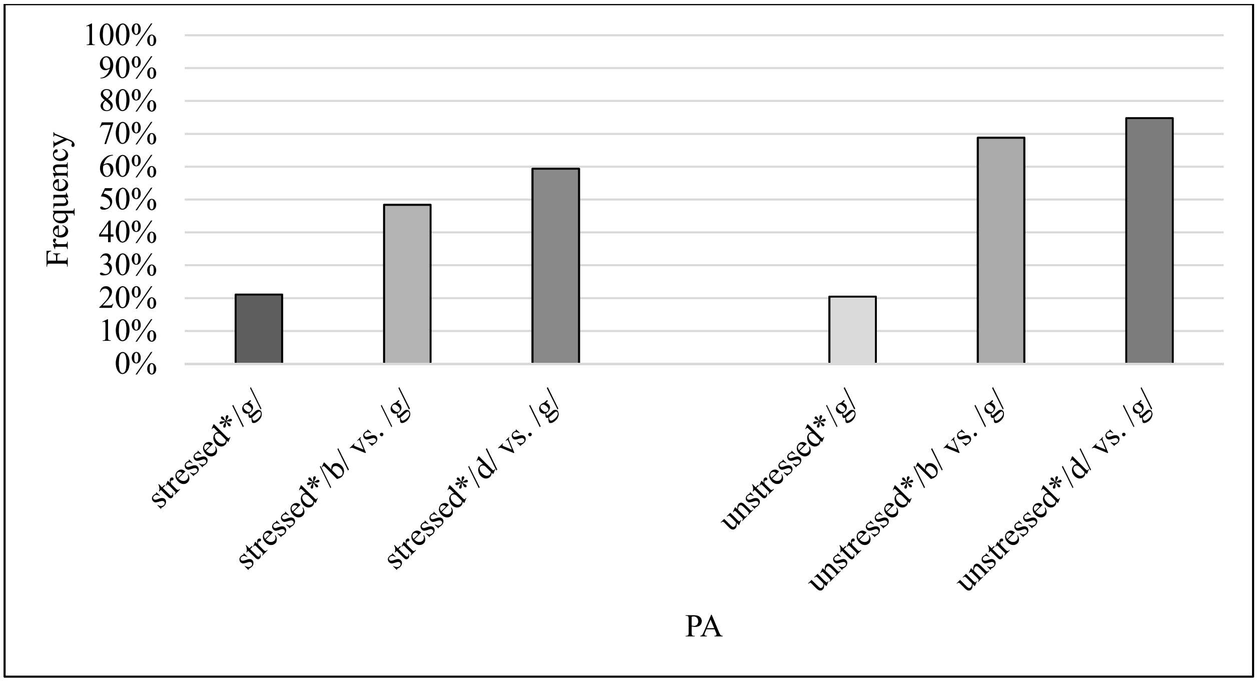
For phoneme and task, there are two notable interactions involving /b/ and /d/, shown in Figure 3.7. For both phonemes there is a significant effect resulting in a preference for the PA to occur in the conversation task, for /b/ (83%) and /d/ (90%), compared to the reading task (45% and 68%, respectively). By contrast, the phoneme /g/ does not interact with task type. These results point to a distinction between careful and casual speech when it comes to the individual phonemes that are pronounced as PAs.

Figure 3.7 PA model: phoneme and task type interactions



Based on the context of Stress, we find /b/ and /d/ again with four significant interactions compared to /g/. As shown in Figure 3.8, the productions of both /b/ (48%) and /d/ (59%) are more likely to be a PA in stressed syllables than /g/ (21%) within the same context. The same discrepancies are found in the unstressed interactions. Both /b/ (69%) and /d/ (75%) are favored in unstressed syllables compared to /g/ (20%). Taken together, these interactions suggest that /g/ is much less likely to be realized as a PA—even in unstressed syllables, where PAs are generally favored.

Figure 3.8 PA model: stress and phoneme interactions

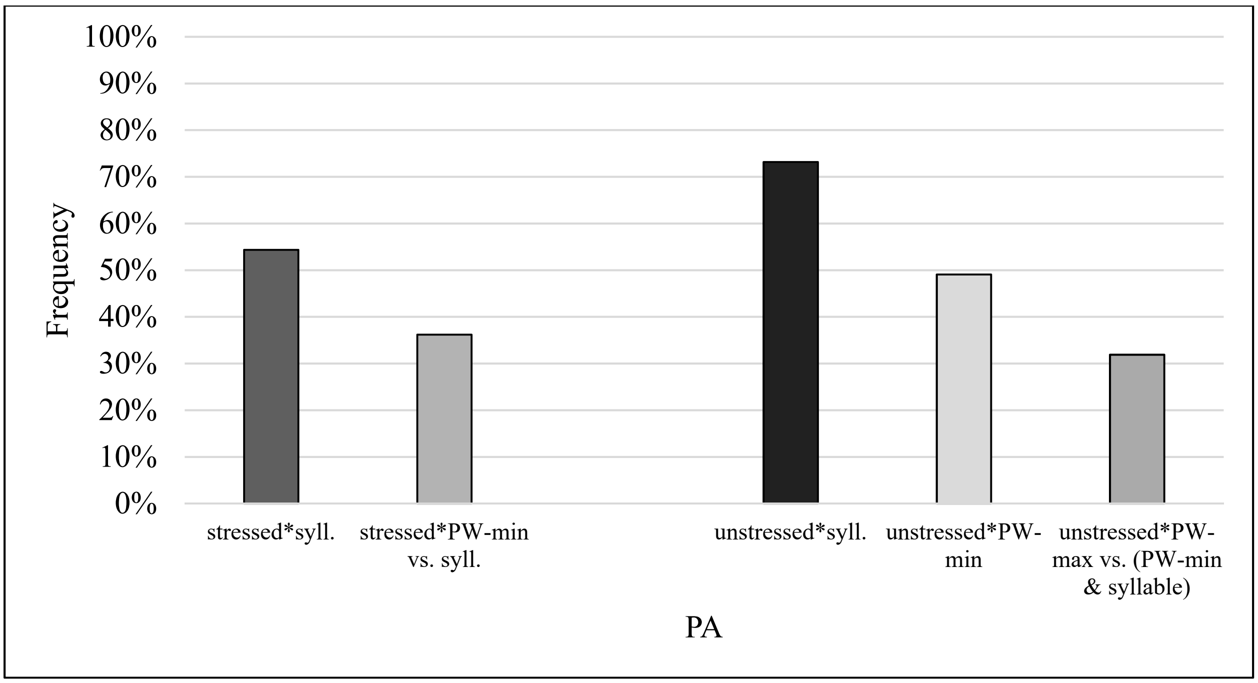


Stress and prosodic domain have three significant interactions, shown in Figure 3.9. First, the frequency of PA allophones is lower in the context of a stressed syllable that is initial in the PW-min domain (36%) compared to a stressed syllable that is medial in the PW-min (54%). Second, the rate of categorical PA is lower in unstressed syllables in the context of the PW-max domain (32%) than unstressed syllables in both the PW-min domain (49%) or syllable level domain (73%).

The role of prosodic structure in mediating lenition can be observed most clearly in the interactions between unstressed syllables and prosodic domains. The frequency of the most lenited PA allophone decreases significantly as the preceding boundary becomes higher in the prosodic hierarchy: syllable < PW-min < PW-max. In stressed contexts, the only significant difference is between the syllable and PW-min levels. The frequency of PAs for the stressed*PW-max interaction (not shown in Figure 3.9) turns out to be the same as for stressed*PW-min, i.e. 36%.

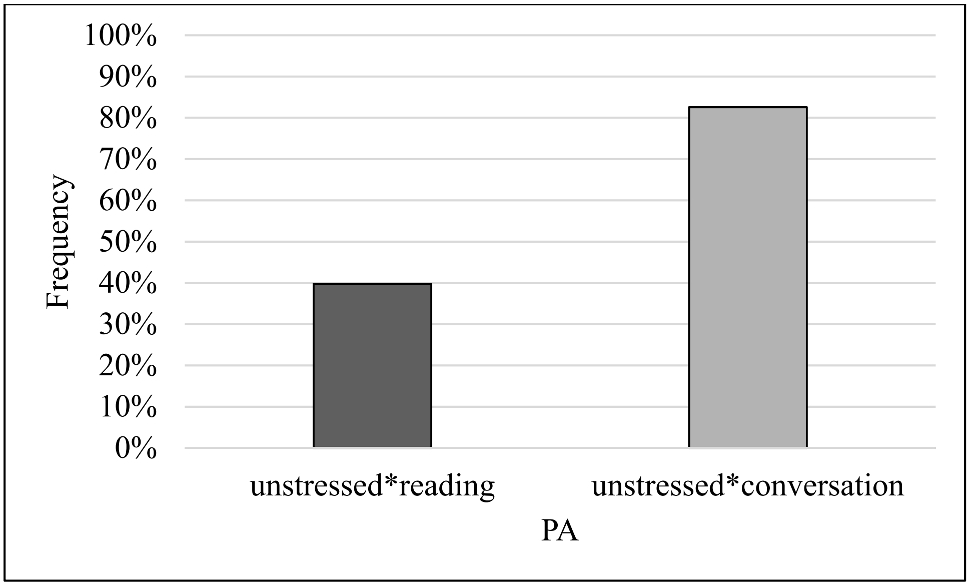
However, the only significant difference is between stressed*PW-min and stressed*syllable. These results suggest that prosodic structure does not condition the distribution of PAs in stressed syllables in the same way as in unstressed syllables. Unstressed syllables allow significant differences to emerge among the syllable, PW-min, and PW-max boundary contexts, but the presence of stress neutralizes the prosodic mediation effect at the word levels.

Figure 3.9 PA model: stress and prosodic domain interactions



For the stress and task interaction there is one significant outcome, illustrated in Figure 3.10. In this context, a PA is more likely to occur in unstressed syllables in the conversation task (83%) compared to unstressed syllables in the reading task (40%).

Figure 3.10 PA model: stress and task type interactions



The interactions between prosodic domain and phoneme resulted in six significant outcomes. For each domain, there are two significant interactions involving /b/ and /d/ once again, shown in Figure 3.11 through Figure 3.13. First, in Figure 3.11, both /b/ (74%) and /d/ (83%) are more likely to be produced as PAs than the phoneme /g/ (25%) within a word-medial syllable domain. At the beginning of the PW-min domain, as shown in Figure 3.12, both /b/ (41%) and /d/ (57%) are more likely to be realized as a PA than the phoneme /g/ (25%) in the same domain. Finally, the interaction between the PW-max domain and phoneme follows a similar pattern to the previous two domains. Figure 3.13 shows that both /b/ (45%) and /d/ (47%) at the PW-max domain boundary are significantly more likely to be pronounced as PAs than /g/ (5%) in the same context.

Figure 3.11 PA model: prosodic domain (syllable) and phoneme interactions

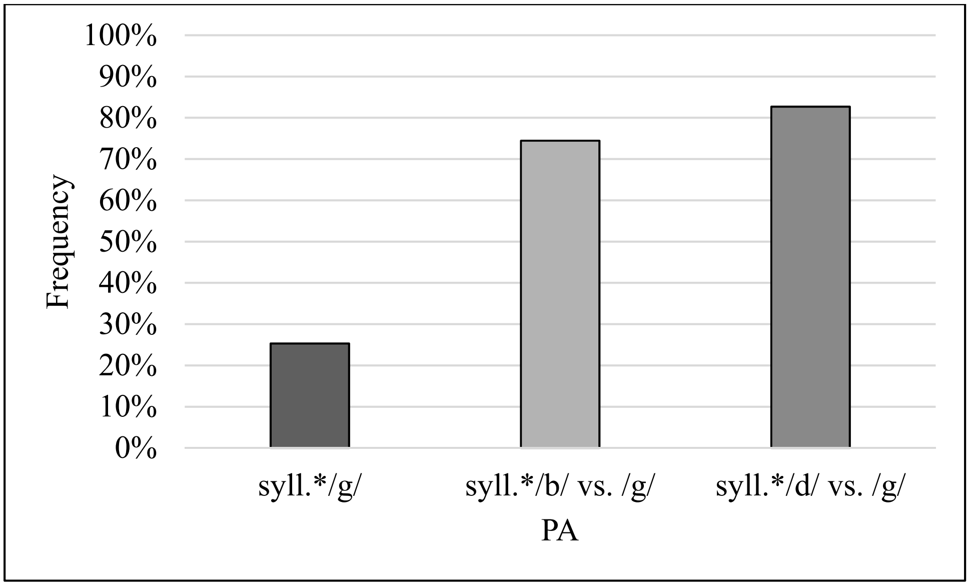


Figure 3.12 PA model: prosodic domain (PW-min) and phoneme interactions

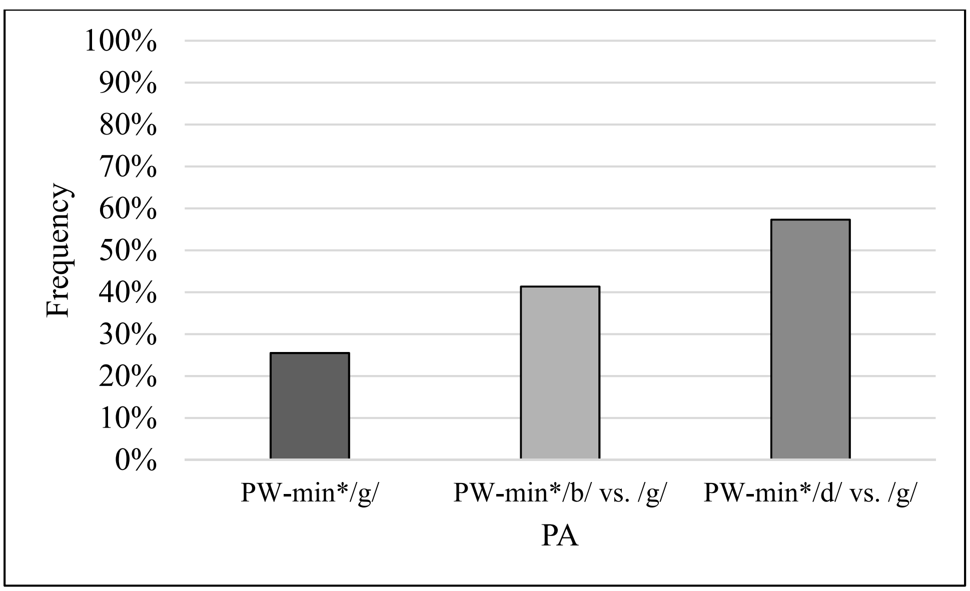
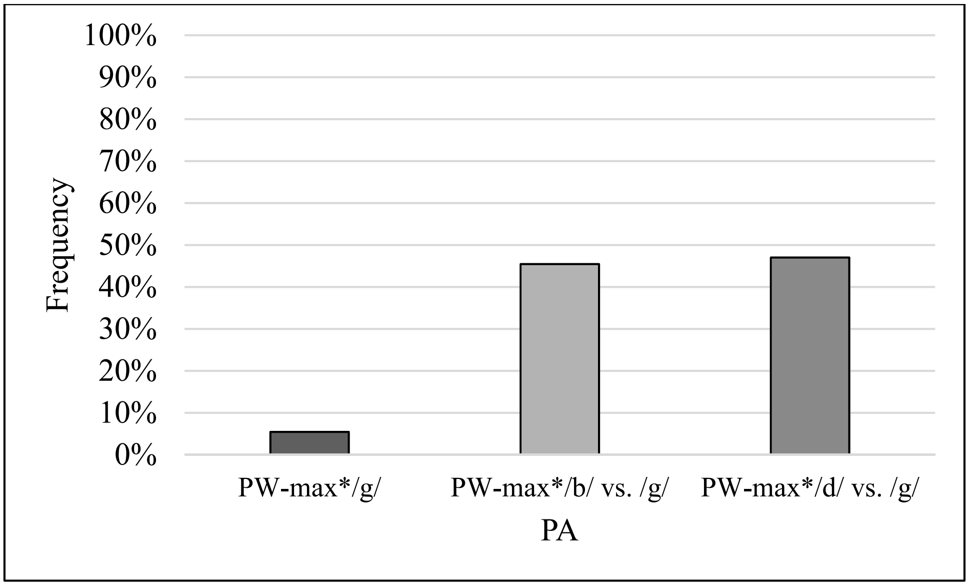
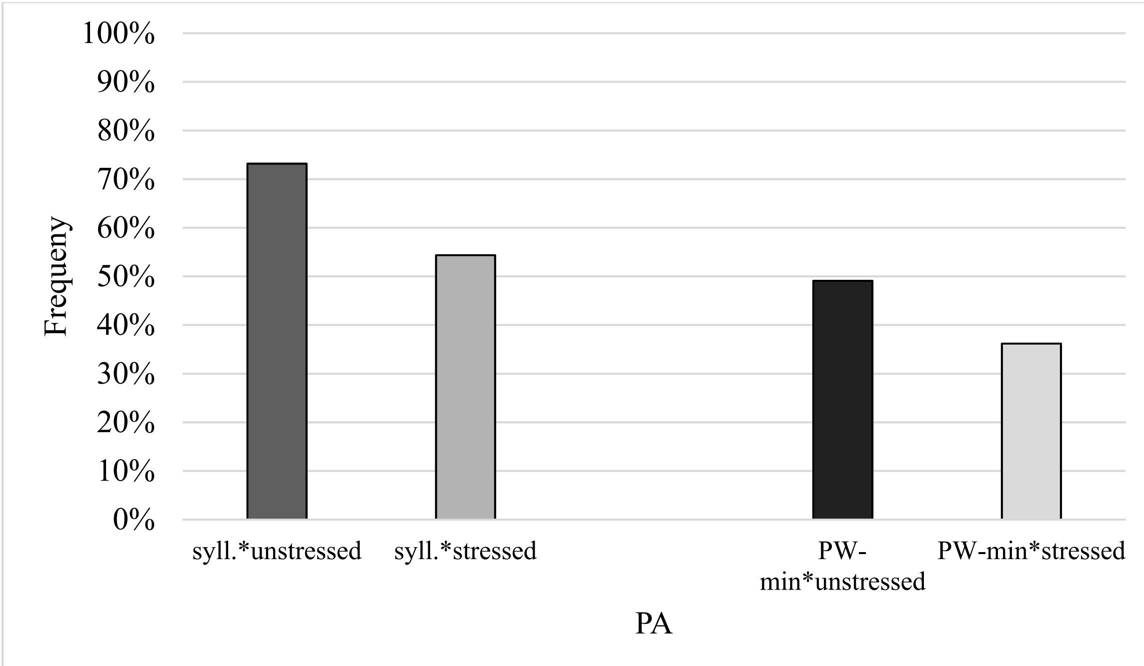


Figure 3.13 PA Model: prosodic domain (PW-max) and phoneme interactions



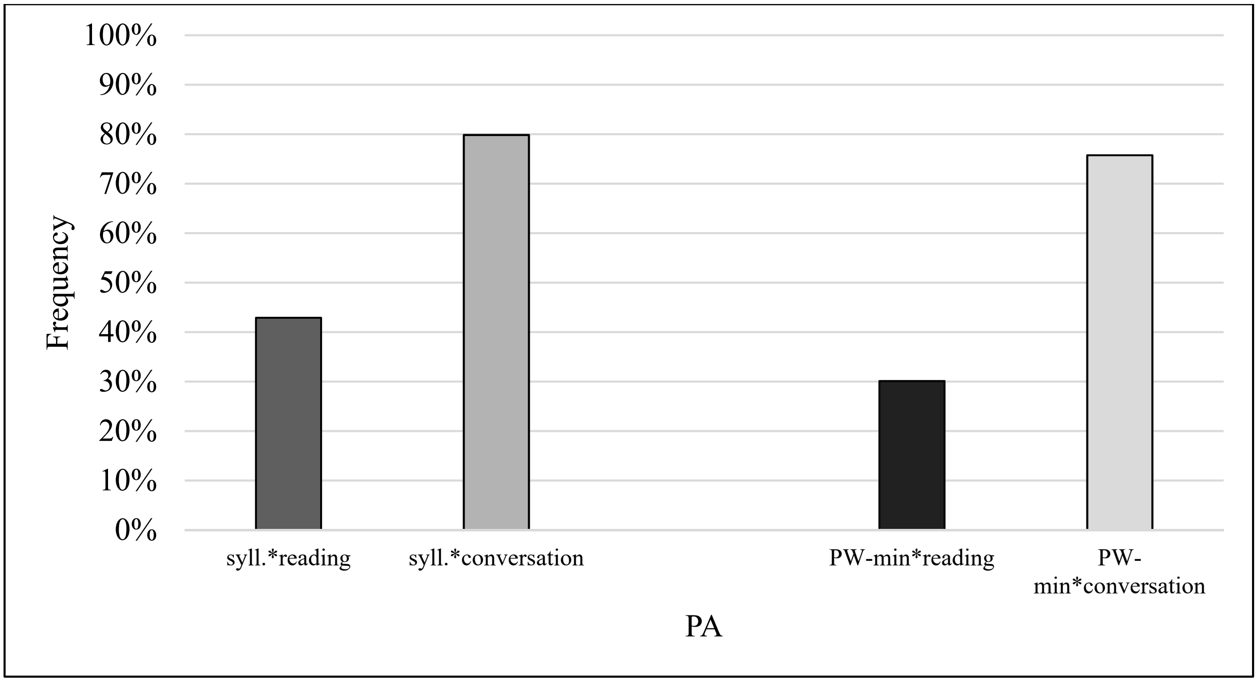
Continuing along with the interactions of prosodic domain within the PA model, we see that stressed segments are significant in two domains, as illustrated in Figure 3.14. In both the syllable and PW-min domains, the presence of stress on the syllable containing the voiced obstruent makes a PA realization less likely in word-medial position (54%) and in PW-min-initial position (36%) as compared to unstressed syllables in the same domains (73% and 49%, respectively).

Figure 3.14 PA Model: prosodic domain and stress interactions



The interactions between prosodic domain and task type in Figure 3.15 reveal that PA allophones are more likely in the conversation task compared to the reading task. Within the syllable domain, PAs occur at a lower rate within the reading task (43%) than the conversation task (80%). Likewise, within the PW-min domain PAs are more likely to occur in the conversation task (76%) than in the reading task (30%).

Figure 3.15 PA Model: prosodic domain and task type interactions



3.2.3 TA model interactions

The interactions between independent variables of the TA model are fewer than those of the PA model but still insightful for understanding how the factors influence the distribution of this intermediate category. The results of significant interactions are outlined in Table 3.6.

Table 3.6 TA model significant interactions

Interaction	Standard Error	p
/b/*Conversation	0.255	0.0001*
Stressed*/b/ vs. /d/	0.206	0.0066*
Stressed*/d/ vs. /g/	1.259	0.0193*
Unstressed*/b/ vs. /g/	0.292	0.0019*
Syllable */b/ vs. /d/	0.161	0.0211*
Syllable */b/ vs. /g/	0.142	<.0001*
Syllable */d/ vs. /g/	0.153	<.0001*
Syllable*Conversation	0.128	<.0001*

There was only one significant interaction for the TA category between phoneme and task type. Figure 3.16 shows the rate of /b/ produced as a TA in the reading task (37%) on the left and in the conversation task (14%) on the right. In this interaction, it is less likely that /b/ will be articulated as a TA in casual speech.

Figure 3.16 TA model: phoneme and task type interactions

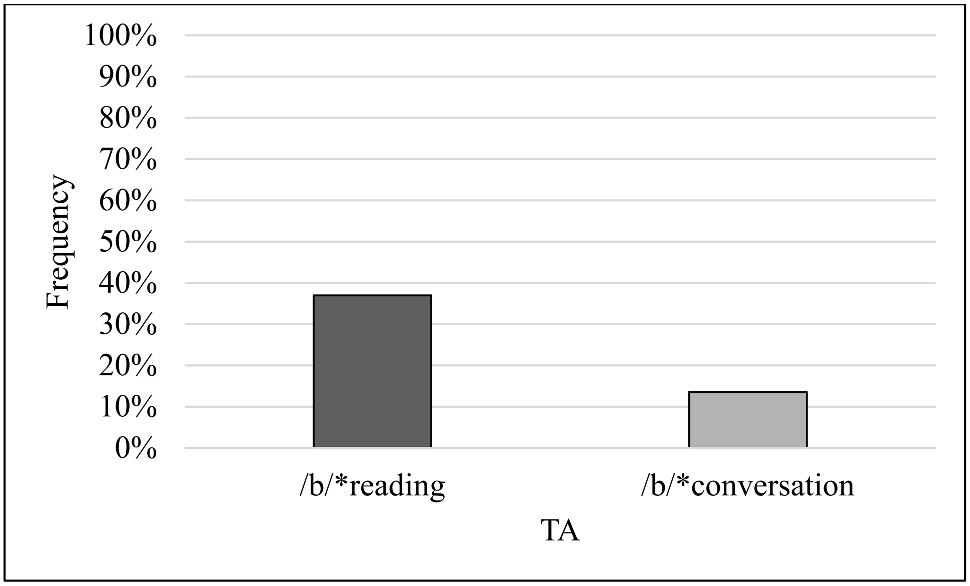
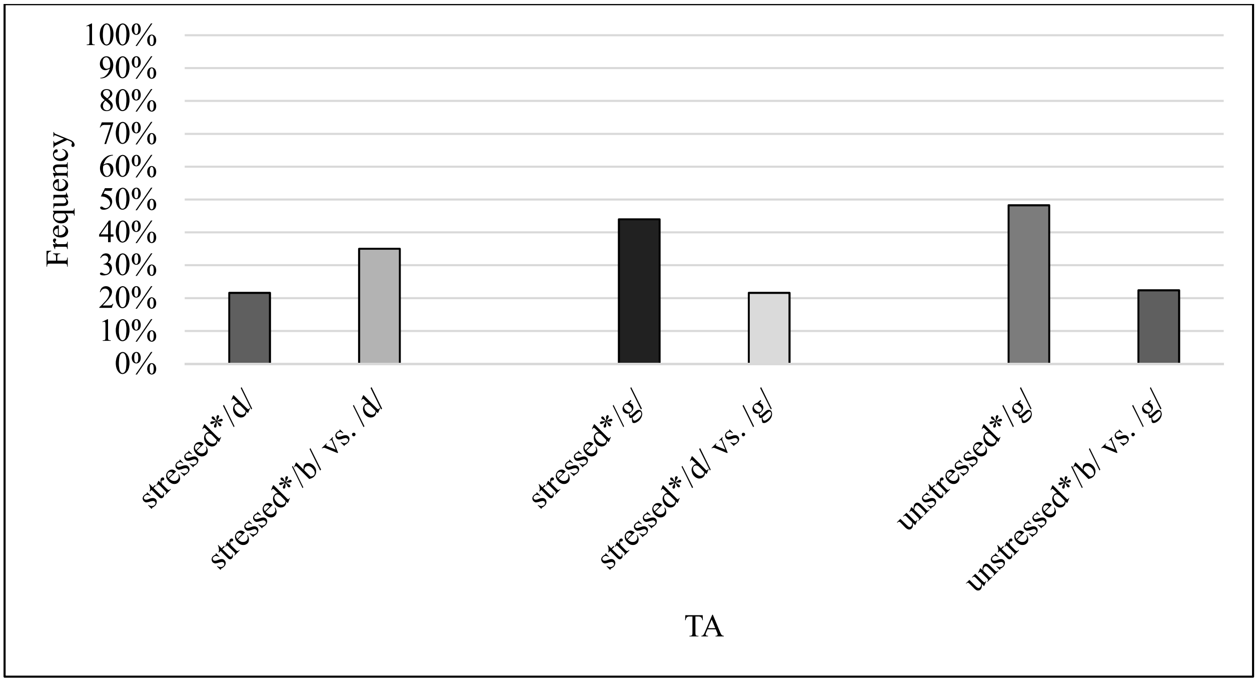


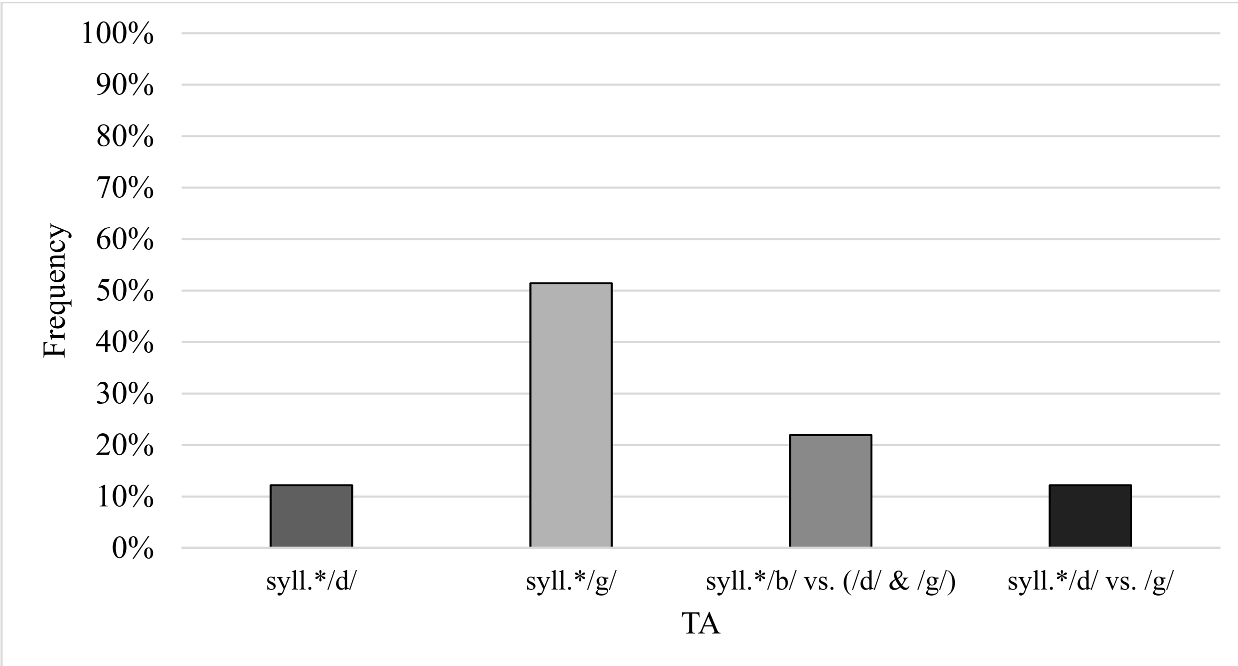
Figure 3.17 presents the significant interactions between stressed and unstressed variables and phoneme. In stressed syllables, the allophone TA is the favored pronunciation of the phoneme /b/ (35%) more frequently than of /d/ (22%). Conversely, the phoneme /d/ is less likely to be produced as a TA than /g/ (44%) in the context of stress. There is no significant difference between phonemes /b/ and /g/ in stressed syllables. In unstressed syllables, the only significant interaction is that /b/ (22%) disfavors the TA realization compared to /g/ (48%).

Figure 3.17 TA model: stress and phoneme interactions



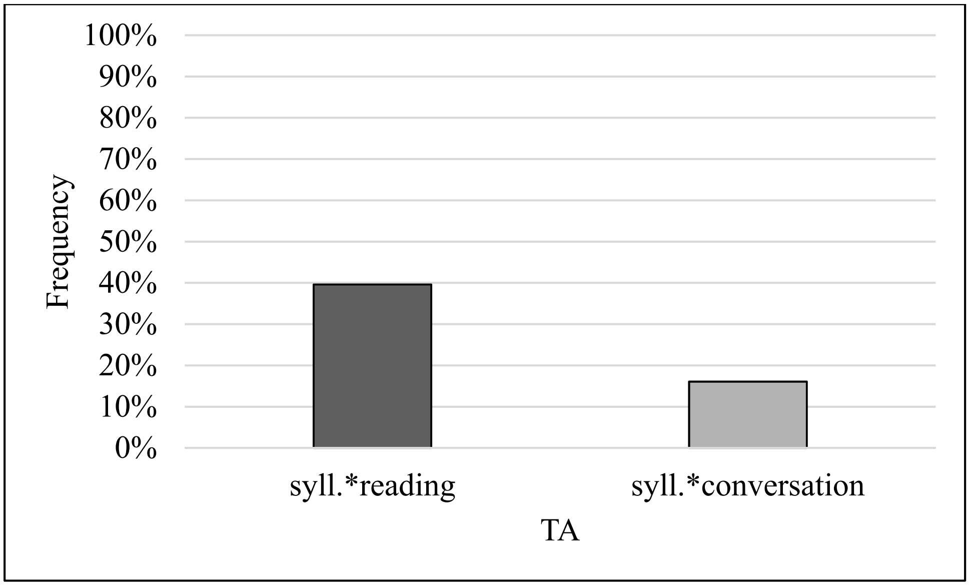
There are four significant interactions for the TA model involving prosodic domain. First, in Figure 3.18 there are three significant results in the relationship between syllable level domain and phoneme. It is more common for the phoneme /b/ (22%) to be produced as a TA in the syllable domain when compared to the rate of /d/ (12%) within the same domain. However, /b/ is less likely to be realized as a TA in this domain as compared to /g/ (51%). It is also less likely that a TA will be produced for the phoneme /d/ (12%) when compared to the rate of /g/ (51%) in this word-medial position.

Figure 3.18 TA model: prosodic domain and phoneme interactions



In the final significant interaction for the TA model between prosodic domain and task, Figure 3.19 shows that within the syllable level domain, a TA is less prevalent in the conversation task (16%) than in the reading task (40%).

Figure 3.19 TA model: prosodic domain and task type interactions



3.2.4 Stop model interactions

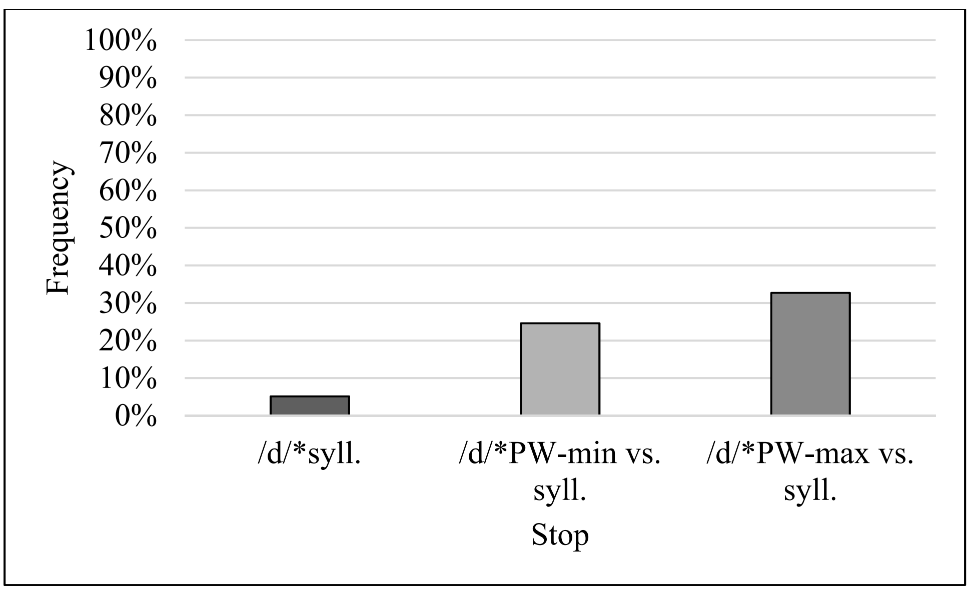
Compared with the previous models, there are far fewer significant interactions for voiced Stops. Only four are outlined in Table 3.7. Interestingly, all of these significant effects involve the phoneme /d/.

Table 3.7 Stop model significant interactions

Interaction	Standard Error	p
/d/*PW-max vs. Syllable	0.363	<.0001*
/d/*PW-min vs. Syllable	0.367	<.0001*
/d/*Conversation	0.281	<.0001*
Syllable*/d/ vs. /g/	0.333	<.0001*

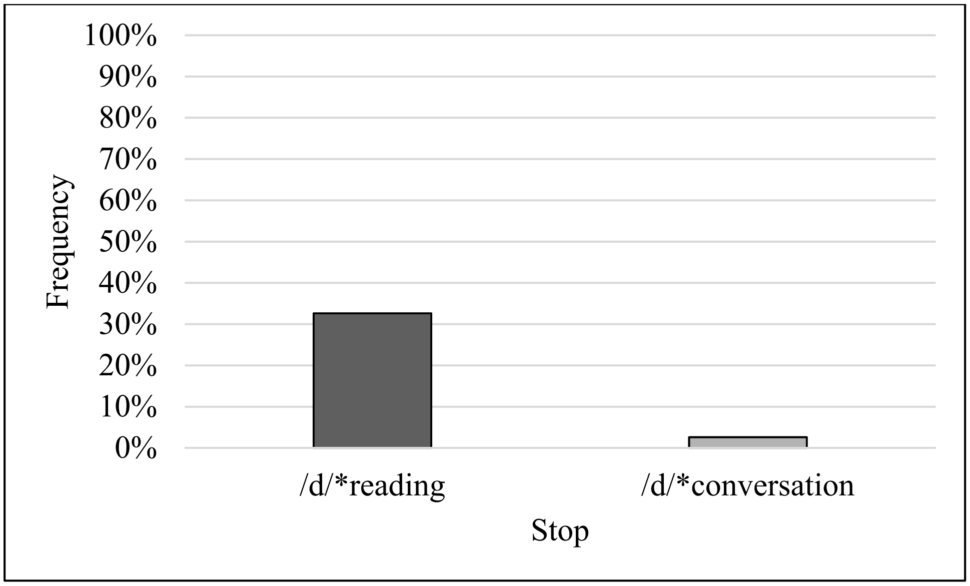
The interaction between phoneme and prosodic somain has two significant results, shown in Figure 3.20. For /d/, a stop is more likely to occur in the initial position of the PW-min domain (25%) and of the PW-max domain (33%) compared to the phoneme /d/ in the word-medial syllable level domain (5%). This clear stepwise pattern from left to right, once again, reveals a prosodic mediation effect, whereby Stops become more frequent as the height of the prosodic domain increases. In comparison to the main effects for the Stop model (see Figure 3.3), whose differences trend in this same direction but fall short of statistical significance, the interactions between phoneme and the prosodic word domains show that there is a prosodic mediation effect, but that it is limited to coronal /d/. This asymmetry probably stems from the fact that (i) /d/ has the most tokens in the data set: 1679 vs. 1217 for /b/ and 1112 for /g/ (see Table 3.1), and (ii) Stops are the least frequent dependent variable category observed overall, especially in the conversation task (see Table 3.3).

Figure 3.20 Stop model: phoneme and prosodic domain interactions



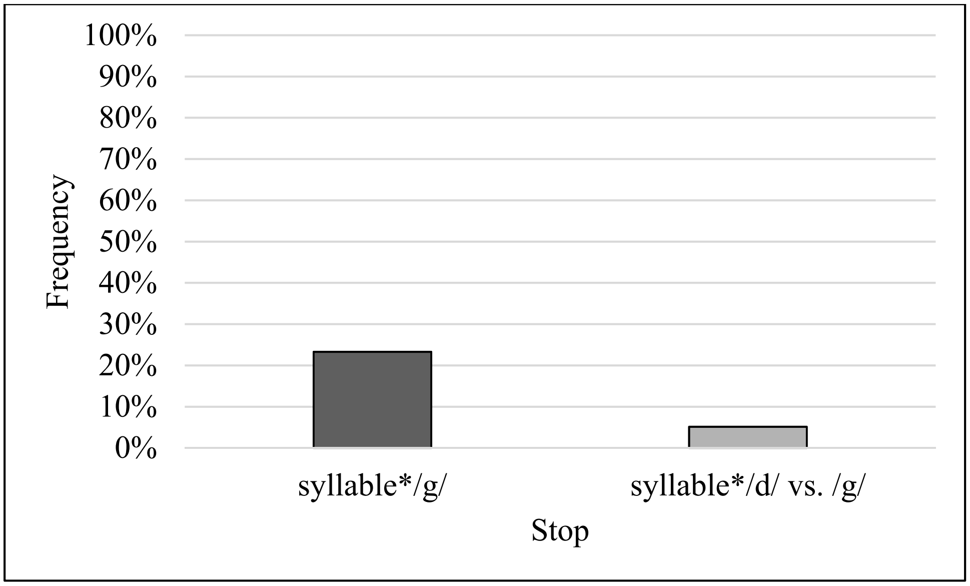
For the interaction of phoneme and task type in Figure 3.21, /d/ disfavors Stop allophones in the conversation task (3%) as opposed to when /d/ occurs in the reading task (33%).

Figure 3.21 Stop model: phoneme and task type interactions



The final significant interaction for the Stop model is between the prosodic domain and phoneme, illustrated in Figure 3.22. Within the syllable level domain, /d/ (5%) is less likely to be realized as a Stop compared to the phoneme /g/ (23%). Interestingly, this same interaction between phoneme /d/ and task was shown to be statistically significant in the PA model but in the opposite direction, with fewer PAs in the reading than the conversation task.

Figure 3.22 Stop model: prosodic domain and phoneme interactions



3.3 Discussion

The aim of this study was to examine the production of intervocalic voiced stops in Colombian heritage speakers of U.S. Spanish. The results, as described in the previous section, show that while there is individual variability, the independent variables of analysis do mediate the alternation between stops and approximants. In this section, I will return to the independent variables, restating the hypotheses from Table 2.2 before presenting the main takeaways from the results.

3.3.1 Phoneme

- **Hypothesis**: The distribution of PA, TA, and Stop allophones of dorsal /g/ will differ in some way from that of bilabial /b/ and coronal /d/.

The results confirm that /b/ and /d/ act similarly compared to each other, but both pattern differently compared to /g/. The highest rate of lenition comes from /d/, as found in previous studies (Amengual, 2019; Blair & Lease, 2021; Broś et al., 2021; Carrasco, 2008; Carrasco et al., 2012; Colantoni & Marinescu, 2010; Rao, 2015), but the analysis of main effects finds no significant difference between /b/ and /d/. Both are more likely to be pronounced as a PA and less likely to be pronounced as a TA than /g/ is, but there are no significant main effects for Stops. Based on these main effects, the ranking of phonemes from most to least lenition is /d/, /b/ > /g/.

Phoneme type also interacts with other independent variables. When the phoneme /b/ interacts with stress, it is less likely to occur as a PA than in the context of an unstressed syllable. For both /b/ and /d/, a PA realization is less likely in both the minimal and maximal prosodic word domains when compared to the word-internal syllable onset. It is also more likely for /d/ to surface as a Stop in both the PW-min and PW-max domains when compared to the syllable domain.

While in the present study the frequency rate of /d/ is higher than that of /b/, there is no significant main effect between the two. The finding that /b/ and /d/ pattern differently than /g/ is in agreement with the results of previous studies that report /g/ to be less likely to lenite than the bilabial and coronal voiced stops (Carrasco et. al, 2012; Eddington, 2011; Figueroa, 2016). The results from the current study differ from studies of other varieties of Spanish in which statistically significant differences motivate a total ranking, from most to least lenition, of /d/ > /b/ > /g/, for example, Argentine Spanish (Colatoni & Marinescu, 2010), Gran Canaria Spanish (Broś et al., 2021), and Costa Rican Spanish (Carrasco, 2008).

Returning to heritage Spanish varieties, the phoneme effects observed in the present study differ from those documented by Rao (2015), who found a significant main effect between the rates of /b/ and /d/ for both the PA and Stop models. In the present study, significant main effects emerge for PAs—not between /b/ and /d/ but between each of the aforementioned phonemes and /g/. However, such main effects are absent from the Stop model. The present study also replicates the findings of Rao (2015) that show significant interactions between (i) phoneme and task type, i.e. /b/ is more likely to be produced as a PA in casual speech than in careful speech, and (ii) phoneme and prosodic domain, i.e. /b/ is less likely to elicit a PA at a word boundary than in a word-medial position. While Rao's (2015) experimental design does not assume prosodic word recursion, the present study finds both the PW-min and PW-max domains to be significant predictors of increased PA frequency for /b/. Using the same dependent variable categories for manner of articulation as the present study and Rao (2015), Blair and Lease (2021) report higher rates of TA allophones for /b/ than those reported here. Similarly, we find coronal /d/ to have the highest rate of PA allophones and dorsal /g/, the lowest. The overall distribution of phonemes is otherwise comparable. Finally, Amengual (2019) reports greater intensity differences, and thus less lenition, for /g/ than /b/ or /d/ as pronounced by simultaneous bilinguals but not by sequential bilinguals. In our study, there are no significant differences between simultaneous and sequential bilinguals for any of the variables. However, our results do confirm the asymmetry between dorsal and non-dorsal voiced stops. Of the three phonemes, /g/ tends to be the most stop-like phonetically.

3.3.2 Stress

- **Hypothesis**: PAs will be less frequent in stressed than unstressed syllables, and conversely, Stops will be less frequent in unstressed than stressed syllables.

The results of the main effects show that stress is a significant predictor of both PA and TA production. In unstressed syllables a PA is more likely, while a TA is more likely in stressed syllables. Interactions between stress and phoneme show that in both stressed and unstressed syllables, /b/ and /d/ are more likely than /g/ to be produced as a PA. In stressed syllables, /b/ is realized as a TA at a higher rate than /d/, and /d/ at a lower rate than /g/, while in unstressed syllables, /b/ is significantly less likely than /g/ to be realized as a TA. In stressed syllables, lenition is less likely in the initial position of the PW-min domain compared to the syllable level. For unstressed syllables, lenition is less likely in the initial position of the PW-max domain compared to the PW-min and syllable.

These results are consistent with previous studies (Carrasco, 2008; Carrasco et al., 2012; Eddington, 2011; Hualde et al., 2011; Ortega-Llebaria, 2004; Rao, 2015) that find more lenition in unstressed contexts and more constriction in stressed syllable contexts. In these previous studies, the analysis of prosodic domains was limited to word-initial and word-medial intervocalic voiced stops, as researchers had not recognized a distinction between the minimal and maximal prosodic word. Including a distinction between PW-min and PW-max domains provides further insight into how prosodic structure mediates lenition at various projections of the word and how such mediation interacts with prosodic prominence, i.e. syllable stress. The inclusion of PW-min and PW-max as independent variables shows that in unstressed syllables, lenition is disfavored in both positions.

3.3.3 Prosodic domain

- **Hypothesis:** PAs will be more frequent at the syllable level than the prosodic word levels, and conversely, Stops will be more frequent at the prosodic word levels than the syllable level.

The expansion of an analysis of voiced obstruent production to include three prosodic domains is inspired by the methodology in Cabrelli Amaro's (2017) study of L2 Spanish leaners. A distinction between the minimal and maximal projections of the prosodic word, beyond the more general label of word-initial, provides insight into the influence of prosodic domain on the production of /b, d, g/ by Spanish speakers of Colombian heritage. As a main effect, there is a significant difference between each of the adjacent levels for the PA model. That is, the model predicts the most frequent lenition in word-medial syllable onsets, less in initial position of the minimal prosodic word, and the least lenition in initial position of the maximal prosodic word. Unlike for PAs, there are no significant main effects predicting TAs across domains. For Stops, the differences trend in the predicted direction but fall short of reaching statistical significance, most likely due to the smaller number of Stop tokens in the conversational task data (see Table 3.3).

The significant interactions with other independent variables also help us understand the effect of prosodic domain on /b, d, g/ production. The relationship between domain and phoneme is the most informative. The phonemes /b/ and /d/ are more likely than /g/ to be produced as a PA at the syllable level. At the minimal prosodic word level both /b/ and /d/ are more likely to be realized as a PA, when compared to /g/. For TAs at the syllable level, both /b/ and /d/ are less likely to be produced as a TA than /g/ in the same context. Finally, at the syllable domain

/d/ is less likely than /g/ to occur as a Stop. At the syllable and PW-min domains, a PA is less likely in stressed syllables. In both the syllable and PW-min domains, a PA is more likely in the conversation task than the reading task. Finally, at the syllable level, a TA is less likely in the conversation task.

Like other studies that compare the distribution of voiced obstruent allophones in both word-internal and word-medial domains (Amengual, 2019; Broś et al., 2021; Carrasco, 2008; Carrasco et al., 2012; Eddington, 2011; Rao, 2015), we confirm with these results that the prosodic domain does mediate the articulation of voiced stops to an extent. At the syllable level word-medially, we still find the most lenition, as indicated by the highest frequency of PA tokens, whereas the lowest frequency of PA tokens is observed at the maximal projection of the prosodic word. The distribution of TAs and Stops follows the expected pattern in terms of the raw frequency distribution of the tokens, as both categories are more frequent than PAs in initial position of the PW-min and PW-max domains compared to the syllable domain. However, the main effects of the regression models are not able to show statistically significant differences in the TA and Stop distributions for any of the three prosodic domains, although the Stops do trend in the predicted direction, becoming more frequent as the position within the prosodic hierarchy becomes higher.

The motivation for the expanded prosodic word Domain comes from Cabrelli Amaro's (2017) study on L2 learners and Zampini's (1997, 1998) initial studies on acquisition of spirantization within the prosodic hierarchy. The present study partially confirms the predictions of Zampini's (1997, 1998) hypothesis that spirantization is acquired in smaller domains (i.e. the syllable level) before larger prosodic domains. She proposes that the intonational phrase is the domain of Spanish spirantization, although more recently, see Bonet (2020: 337), who argues that both regressive nasal place assimilation and spirantization of voiced stops operate over the entire utterance. While the methodology of the present study limits the prosodic domain variable to just syllable, PW-min, and PW-max, the regression models confirm significant effects for these levels. These results differ from Cabrelli Amaro's (2017) intermediate and advanced L2 learners, who do not provide evidence of an intermediate acquisition stage for spirantization that distinguishes between the PW-min and PW-max domains.

3.3.4 Task type

- **Hypothesis:** PAs will be more frequent in conversational than careful speech, and conversely, Stops will be more frequent in careful than conversational speech.

The distinction between careful and casual speech can be measured by the effect of task type on the articulation of intervocalic /b, d, g/. As a main effect, task type is a significant predictor of the PA distribution, with lenition being more common in the conversation task. There are no significant main effects for TAs or Stops, although both categories tend to be less frequent in the conversation task. As described in the previous subsections, phoneme interactions show more lenition for /b/ and /d/ in the conversation task. For the stress variable, there are higher rates of lenition in unstressed syllables in the conversation task. There is also more lenition in the conversation task as revealed by significant interactions with the syllable and PW-min domains. There are fewer TAs at the syllable level in conversations. Finally, /d/ is less likely to surface as a Stop in the conversation task when compared to the reading task.

These results confirm the anticipated distinction between task types. In the casual speech elicited during the conversation task, we see more independent variables predicting more lenition. Another consideration regarding task types is that in reading, there is a visual cue to the location of word boundaries. In careful speech style, it is possible that lenition is disfavored in the word-initial position by the presence of a clear visual space between words, for both the minimal and maximal prosodic word projections, where the alternation between Stop and approximants occurs. Other studies have also found similar evidence of task type being a significant predictor of voiced stop lenition by heritage Spanish speakers (Rao, 2014; 2015), and monolingual Spanish dialects (Carrasco, 2008; Carrasco et al., 2012; Figueroa, 2016). Martínez-Gil (2020) suggests that "speech tempo is not a preeminent factor in the stop ~ spirant allophonic distribution of voiced obstruents in Spanish" (47). Together with the results of previous experimental studies, the main effects and interactions presented here for Colombian heritage Spanish suggest that task type *is* relevant to the distribution, whereby the conversation task favors lenition.

3.4 Social factors

In the preparation of the methods and design of the study, as detailed in Chapter 2, participants were classified by their location, generation, and as simultaneous or sequential bilinguals. However, the inclusion of generation, speech community, and order of language acquisition did not elicit any significant effects for any of the tests when included in the independent variables of the statistical models. In their study of heritage Spanish learners, which examined only careful speech, Blair and Lease (2021) report generation to be a significant factor leading to lower rates of lenition as generations increased. Conversely, the other social variables included in their study, i.e. contact hours with Spanish and age of acquisition of Spanish, were not significant predictors of voiced stop lenition. In future research on U.S. varieties of Colombian heritage Spanish, a more expansive data set with carefully stratified groupings may provide further insight into the roles that social factors play in mediating allophonic variation. As none of these factors seems to condition the production of voiced stops in our current data set, the following section will look at the distribution of the categorical allophones, following the descriptive analysis in Rao (2015), in relation to individual language use.

3.5 Individual variation

The production of /b, d, g/ as detailed in Table 3.2 demonstrates a certain level of individual variation among participants. Previous studies on heritage speakers appeal to current and early age language use and exposure as explanations of current patterns (Amengual, 2019; Au et al., 2008; Oh & Au, 2005; Rao, 2015). In general, these studies report different patterns of spirantization for two groupings of participants: (i) those who had either less exposure to Spanish in early childhood or simultaneous exposure to both English and Spanish, and (ii) those who had either more exposure to Spanish in early childhood or sequential exposure, first to Spanish then to English at around ages 5 or 6, as well as those who use Spanish more often in their current language practices. Following this line of inquiry, we will look in more detail at the language background surveys of participants, based on their distribution by frequency of the dependent variable categories. Table 3.8 presents the same data found in Table 3.2 showing the distribution of tokens by participant, but this time with individuals grouped according to different rankings of dependent variable categories based on the raw frequencies.

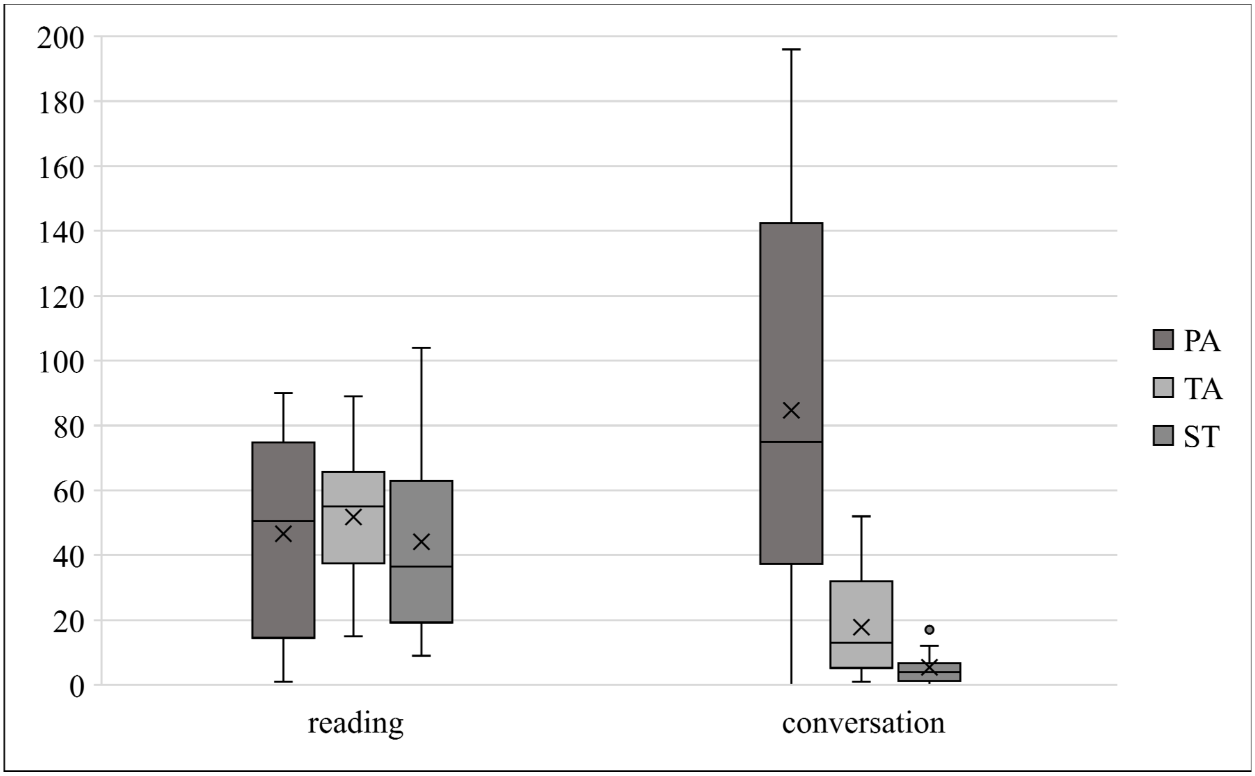
Table 3.8 Summary of participant realizations grouped by distribution pattern

Distribution	Participant	PA		TA		Stop	
		n	%	n	%	n	%
PA > TA > ST	María	186	54.07%	101	29.36%	57	16.57%
	Lollipop	212	63.86%	98	29.52%	22	6.63%
	MommaKat	123	51.68%	100	42.02%	15	6.30%
	Carmen	182	57.23%	80	25.16%	56	17.61%
	Dalia	198	65.78%	73	24.25%	30	9.97%
	Sergio	170	73.28%	33	14.22%	29	12.50%
	Janine	206	50.37%	119	29.10%	84	20.54%
	Mariela	130	56.03%	64	27.59%	38	16.38%
	Esperanza	110	59.46%	66	35.68%	9	4.86%
	Katrina	108	48.00%	77	34.22%	40	17.78%
	Victor	108	54.00%	51	25.50%	41	20.50%
PA > ST > TA	Andrea	164	71.93%	24	10.53%	40	17.54%
	Marby	148	47.74%	56	18.06%	106	34.19%
TA > PA > ST	Lola	38	25.85%	91	61.90%	18	12.24%
ST > TA > PA	Liliana	1	0.70%	50	34.97%	92	64.34%
	Maximos	17	10.37%	31	18.90%	116	70.73%

Eleven of the sixteen participants produced more PAs than TAs, followed by Stops. The majority distribution confirms that in intervocalic positions, most participants produce the least amount of Stop allophones and successively greater amounts of approximants, with PAs being the most frequent. That is, the majority of participants prefer the most open approximant, although the two more constricted allophones nonetheless constitute from 25 to 50% of the total productions depending on the individual. The remaining five participants varied in their overall allophone distributions, which diverge from the majority pattern shared by the other eleven participants. Following Rao (2015), we will consider the language practices and timing of language exposure of these participants for more insight into their commonalities, based on the responses in the qualitative survey on language background and current language use.

While the frequencies presented in Table 3.8 are helpful in looking at the overall patterns of individual variation, the lack of stratification of the variables by individuals in the conversation task makes it difficult to draw concrete conclusions based on these numbers. As previously touched on near the beginning of Section 3.2, Table 3.3 shows the descriptive statistics for each task type. Figure 3.23 below shows a boxplot of the same data. There is more variability in the conversation task, particularly in the number of PAs.

Figure 3.23 Boxplots of allophone frequency by task type



A closer look at the ranges of token frequency for the dependent variable categories in Figure 3.23 shows variability in the quantity of tokens realized by the participants, especially for PAs in the conversation task. Therefore, the qualitative descriptions offered below are only a cursory analysis and not a full representation of social factors that might turn out to be statistically significant within a larger data set. A full table of individual token distribution by task can be found in Appendix D.

Two speakers, Andrea and Marby, produced PAs the most, as in the majority pattern, but show a reversal in the relative frequencies of the other allophones, with Stops occurring more often than TAs. Their divergence from the majority distribution is not as strong as Lola, Liliana, and Maximos who produced relatively few tokens in the conversation task overall (see below). In their conversation task data, Andrea follows the majority pattern with a PA rate of 86.05% (n=74), TA 10.47% (n=9), Stop 3.49% (n=3). For Marby, in the conversation task she produced a higher rate of PA at 79.88% (n=135) and the same rate for TA and Stop at 10.06% (n=17). Both participants report always using Spanish with both maternal and paternal grandparents before the age of 5. Marby, currently in New Jersey, was born in Colombia. All interactions with family and community members at an early age are reported to be always in Spanish. Andrea, a third-generation speaker in Miami. reports using mostly English with her parents, siblings, and friends before the age of 5. Additionally, she reports using both languages equally with cousins, other family members, and local community members for early age language practices. After the age of 5, there is a clear shift for Andrea towards more English language use while Marby maintains always Spanish interactions through high school. For current language use, Andrea reports hearing Spanish daily, while Marby reports multiple times a week. Both participants report interacting with Spanish multiple times a week in other types of communication (speaking, reading, and writing). However, the frequency reversal of ST > TA observed for these two participants might turn out to be merely apparent, given the uneven number of tokens available for analysis from the conversation task data. Nevertheless, both Andrea and Marby prefer the most open approximant allophone, as in the majority pattern.

Lola is the only participant who has a higher rate of TA over other realizations. This distribution is limited to the reading task, as she only produced three tokens in the conversation task. She is a third-generation speaker in Miami and a simultaneous bilingual. In early childhood, she reports using Spanish always with her maternal grandparents and mostly Spanish with her paternal grandparents. As a child, she also used both languages equally with her mother, cousins, other family members, and community members, although with her father, siblings, and friends, she reports having used mostly English.

In her current language use, Lola continues to use mostly Spanish with her maternal and paternal grandparents. She now uses both languages equally with friends, coworkers, and community members. With her mother, father, cousins, and other family members she reports using mostly English; finally, she reports always using English with her siblings. For other types of interactions, Lola reports hearing and speaking Spanish daily, while reading and writing multiple times a week.

Liliana and Maximos produced more Stops than TAs or PAs. Liliana generated only 2 tokens in the conversation data, while Maximos produced 20. Together with Lola, these speakers yielded the fewest tokens in the conversation task. Therefore, the quantitative grouping of these participants is based primarily on their reading task distribution. While both are simultaneous bilinguals, a deeper look into their language background shows a dominance of English in their language exposure and practice in both early childhood and current language use.

Liliana is a third-generation speaker in Miami. She reports using both English and Spanish equally with her maternal grandparents in early childhood. With her paternal grandparents, mother, and community members she reports using mostly English. Finally, she reports always using English with her father, siblings, cousins, and other family members. In her current language use, the only main shift is with her maternal grandparents to using mostly English and always English with her mother. When interacting with Spanish, Liliana reports hearing Spanish daily, speaking and reading multiple times a week, and writing only in certain situations. She lists the people she uses Spanish with the most to be her maternal and paternal grandmothers and local community members.

Maximos is a second-generation speaker in New Jersey. He reports all current and early childhood interactions to be always in English. Despite this, he reports hearing Spanish multiple times a week and reading in certain situations. He does not report speaking or writing in Spanish with any frequency. He reports using Spanish the most with his mother, *tías* 'aunts', and cousins.

Liliana and Maximos are the only participants in the study to report speaking Spanish "Not well at all." Liliana reports understanding the language "moderately well". Both participants report taking Spanish classes for non-native speakers at some point in their education. That education and primarily maternal figures in their lives seem to be the sources of Spanish language exposure in their lives.

More data from a wider pool of participants will aid in a better understanding of these sociolinguistic factors. For now, the current indicators of early childhood and current language practices appear to be the criteria that single out Lola, Liliana and Maximos as the subgroup of participants who do not follow the expected pattern distribution of PA > TA > ST. English has had and continues to have a dominant role in the lives of these participants.

3.6 Conclusion

The aim of this chapter was to present the results of the reading and conversational tasks in order to better understand the alternation between voiced stops and approximants in intervocalic positions. This also included a closer look at the factors of phoneme, syllable stress, prosodic domain, and task type. The results show that participants follow an expected pattern preferring lenition in both /b/ and /d/, in unstressed syllables, the syllable onset position within a minimal prosodic word, and in casual speech within the conversation task. Participants that diverge from these anticipated patterns were found to have similar characteristics in their early age and current language practices that indicate a different set of constraints motivating these realizations. The next chapter develops an analysis in Optimality Theory that accounts for the theoretical underpinnings of the quantitative phonetic results presented in this chapter.

CHAPTER 4: FORMALIZING SPIRANTIZATION AS CONTINUITY LENITION

4.1 Introduction

This chapter approaches the spirantization of intervocalic voiced stops in U.S. Spanish of Colombian heritage from the theoretical perspective of contemporary generative phonology. We use phonetically-based Optimality Theory as an analytical framework for understanding patterns of variation and the grammars that give rise to them. The chapter begins by critiquing the conventional view that spirantization is driven by articulatory factors (Section 4.2) and then motivates the alternative view that perceptual factors are primarily responsible for the complementary processes of lenition inside prosodic constituents and fortition at their edges (Section 4.3). In intervocalic position, a lower-intensity consonant produces a greater drop relative to the surrounding vowels, whereas a higher-intensity consonant results in a flatter intensity contour across the [VCV] sequence. Because lenition increases the intensity of intervocalic consonants, its functional basis therefore may be to "convey to the listener that the current prosodic constituent is continuing rather than a new one beginning" (Kingston, 2008: 16). Conversely, fortition at the edges of prosodic domains (Keating, 2006) decreases consonantal intensity and can be understood as signaling the beginning of a new prosodic constituent, thereby complementing the medial lenition pattern. In adopting this approach to the interaction between prosodic structure and consonant strength, we follow Katz's (2016) classification of spirantization as a type of *continuity lenition,* which is "driven by preferences for preserving auditory continuity inside prosodic constituents and maximizing auditory disruption at the edges of constituents" (44).

Drawing upon previous phonetic studies of Spanish varieties, Section 4.5 motivates a scale of relative consonantal intensity that lends further empirical support to Katz's formal approach, in which intensity plays a central role. Crucially, this scale can accommodate the dependent variable categories used both in Rao's (2014, 2015) studies of U.S. heritage Spanish and in the production experiment with Colombian heritage participants described in Chapters 2 and 3 of this dissertation.

Section 4.6 develops a formal analysis of intervocalic spirantization. Based on the scale of relative consonantal intensity, we define a family of markedness constraints that establish segmental intensity thresholds for medial and initial positions in each domain of the prosodic hierarchy. The complementary processes of medial lenition and initial fortition within a given prosodic constituent are optimized by one and the same segmental INTENSITY constraint. These constraints exist in a specific-to-general, or stringency, relationship (de Lacy, 2004), such that any candidate violating a more specific INTENSITY constraint necessarily violates the more general INTENSITY constraints. If a consonant is deemed too disruptive inside some prosodic domain, then so are all more disruptive consonants inside that domain and inside all larger prosodic domains. Conversely, if a consonant is not disruptive enough at the edge of some domain, then neither are all less disruptive consonants at the edge of that domain and at the edge of all smaller domains. The more INTENSITY violations a target consonant incurs relative to its prosodic position, the less harmonic the candidate containing that consonant. The cumulative assignment of violations thereby obviates the need to stipulate a universal constraint ranking in order to generate predictions about possible grammars and surface distributions. We present a basic typology of spirantization as prosodically driven continuity lenition that can also incorporate the effects of phoneme, stress, and task that were uncovered in Chapter 3 for U.S. Spanish varieties of Colombian heritage.

Section 4.8 explores the cross-linguistic predictions of the basic model. Empirical support comes from patterns that are attested in Balkan and Istanbul varieties of Judeo-Spanish. Further laboratory work on prosodically driven continuity lenition is encouraged, especially among domains of the prosodic hierarchy higher than the prosodic word, which have not been systematically investigated in Spanish.

Section 4.9 summarizes and concludes the chapter.

4.2 Is lenition driven by articulatory factors?

Voiced stop lenition in Ibero-Romance languages is commonly understood and analyzed in terms of articulatory factors. With respect to spirantization in Spanish, Martínez-Gil (2020: 40-42) classifies previous studies into four major types: classical (segmental, linear), autosegmental, Optimality Theory (henceforth, OT), and recent experimental work. Although they make different assumptions about the nature of phonological representations, the mapping of underlying to surface forms, and the roles of phonology and phonetics in the alternation, generative studies commonly take spirantization to be speaker-based, resulting from either (i) a reduction in the degree of effort required to articulate voiced stops, especially when preceded by a more open segment, or (ii) a progressive assimilation of the feature [continuant], which spreads from a preceding segment to a following voiced obstruent. Analysts pursuing the first type of explanation typically follow Kirchner (1998, 2001), who proposes a computational, mass-spring model of articulator movement in which the force required for displacement, while holding time constant, serves as a proxy for articulatory effort. Using a framework that incorporates phonetic representations and constraints along with phonological ones within a single OT grammar, Kirchner formalizes markedness constraints of the LAZY family to account for the production of lenited segments as an effort reduction strategy. Constraint interaction formally captures the ways in which consonant lenition is gradiently conditioned by linguistic factors such as the openness of flanking segments, which relates to articulator displacement, and by stylistic factors such as rate of speech, which relates to time. Piñeros (2002) favors Kirchner's effort-based approach over accounts that invoke stricture assimilation, observing that in the process of spirantization,

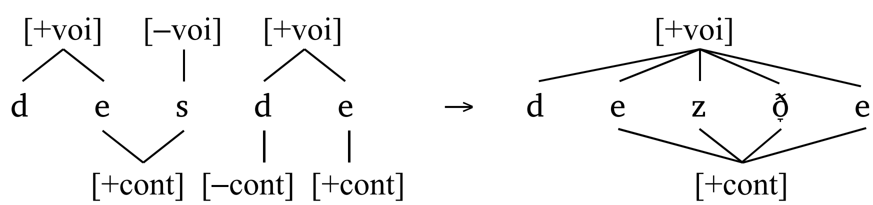
> "a segment reduces the degree of oral closure, which brings the oral pressure down and allows voicing to emerge at a lower effort cost. That is to say that the motivation that lies at the core of spirantization is not to promote agreement in stricture values among adjacent segments (assimilation), but actually a drive to reduce articulatory effort while maintaining the voicing of a segment that is originally intended to have complete oral closure" (394).

However, Piñeros diverges from the proposal that LAZY constraints are phonological and situates them instead within the phonetic implementation component, which he assumes is also constraint-based. There, they penalize the amount of effort required to articulate segments in various left-hand contexts and at different rates of speech. Piñeros argues that voiced obstruents are stops in the output of the phonology and that in the phonetics, faithfulness to stricture interacts with LAZY constraints, giving rise to the gradient variation in spirantization that is observed across segmental contexts and speech styles. Constraint re-ranking accounts for dialectal variation in the contexts of lenition, which is restricted to postvocalic position in relatively more "conservative" varieties but applies even after consonants and glides in Spanish more generally.

The most recent appeal to articulatory effort reduction is made by Colina (2020: 20), who formalizes a hierarchy of markedness constraints in the phonology to account for the avoidance of voiced stops in segmental contexts that are increasingly more effortful, i.e. after a consonant, after a glide, and after a vowel. She argues that voiced obstruents are underspecified for the feature [continuant] in both the input and output representations of the phonology and that these targetless segments persist into the phonetic implementation component (Keating, 1985; also see Colina, 2016), resulting in variable and gradient degrees of constriction as a function of the surrounding context. In general Spanish dialects, output underspecification is the optimal phonological repair that leads to a reduction of articulatory effort at the phonetic level and yields gradient variation. In the stop dominant varieties of American Spanish, speakers are argued to have stored voiced stops in their lexical representations and to rank faithfulness higher against the effort-based markedness hierarchy, such that spirantization is blocked after a consonant or glide and applies only after a vowel. Both Piñeros and Colina assume a derivational ordering of phonetic implementation after the phonological component. The main difference is that LAZY constraints are interpreted by Piñeros as "low-level linguistic principles" (394) of phonetic implementation but as phonological markedness constraints by Colina (2020), who further argues that "the high degree of phonetic gradience in aperture in continuant allophones in Spanish spirantization, which is generally dependent on adjacent sounds, is phonetic and the result of output underspecification (i.e. at the output of the phonology)" (12).

The most recent example of an analysis based on continuancy assimilation is Martínez-Gil's (2020) use of an AGREE constraint in OT that assigns "a violation for every voiced obstruent that does not agree for the feature [cont] with a preceding segment" (57). This constraint achieves the same result as progressive assimilation in pre-OT rule-based analyses but does so by specifically requiring the agreement of adjacent features. For American Spanish varieties that limit spirantization to the postvocalic context, AGREE must be defined more specifically so that it applies only after a preceding nuclear vowel. Across Spanish dialects, spirantization interacts with a number of categorical phonological processes, including voicing assimilation, devoicing, total assimilation, vocalization, and velarization. For this reason, Martínez-Gil argues against phonetic accounts of spirantization, which instead must be part of the phonology (see also Palmada, 1997, who makes the same argument for Ibero-Romance more generally). He proposes that spirantization, “analyzed as an assimilatory process, and voicing assimilation can be formally accounted for as a minimization of articulatory effort […] by the readjustments in the autosegmental configuration, without the need to resort to an effort-reducing LAZY family of constraints” (51). For example, the autosegmental input representation of *desde* ‘since’ in (13) contains alternating opposite values of the features [voice] and [continuant] and is formally more complex than the output representation, in which the relevant segments share just a single positive specification for each feature:

(13)



Thus, Martínez-Gil’s approach incorporates articulatory effort as a motivation for lenition processes. The difference is that effort reduction is reconceptualized in more formal, categorical terms as a simplification of the phonological output representation, without referring to gradient degrees of articulator displacement, time, and force in the phonetic component, and without having to resort to underspecification.

The common denominator among the OT accounts reviewed above is that they situate the explanation for lenition entirely within the domain of the speaker. Whether to ensure stricture agreement or a less effortful articulation, markedness constraints govern the shape of the speaker’s output, without regard to listener-based factors. Martínez-Gil (2020) provides a purely phonological account of spirantization and its interaction with other processes in the speaker’s grammar, in which a language-specific phonetic component has little to no role to play. For Piñeros

(2002) and Colina (2020), phonetic implementation takes the output of the phonology and converts it into a fully specified articulatory plan by providing all the language-specific gradient details necessary for speech production. Speaker-based accounts such as these do not appeal to perceptual factors.

4.3 The functional basis of lenition is perceptual

Kingston (2008) lodges serious complaints against the view that lenition processes serve to reduce articulatory effort. His main argument is that effort-based accounts of spirantization are implausible

> "because the differences in effort between the lenited and unlenited pronunciations are so miniscule that they can hardly be what motivates a speaker to lenite. Both the differences in the distance the articulators travel (mere millimeters) and the time scales (at most tens of milliseconds) are much too small for effort to differ detectably between the two pronunciations" (1).

His second criticism concerns the relationship between displacement and time in Kirchner's equation of articulatory effort with the force required for movement. When a consonant undergoes lenition next to a vowel or another consonant of greater aperture, the active articulator fails to move all the way to its original constriction target, resulting in articulatory undershoot (Lindblom, 1983). The math of Kirchner's (1998, 2001) mass-spring model predicts that an articulatory gesture is more effortful (i.e. requires more force) when its movement takes place over a longer distance or within a shorter time span. Kirchner argues that articulatory undershoot next to a more open sound results from the speaker's attempt to expend less effort within a given amount of time, as determined by a particular ranking of faithfulness and LAZY constraints. According to Kingston (2008), a problem with this approach is that, in reality,

> "speakers choose articulatory targets and then execute them with the speed necessary to reach them. An articulatory target is not undershot because the speaker did not speed up enough to reach the intended target, but instead because the speaker chose that smaller articulatory movement and moved the articulators only fast enough to reach that less distant target […] the speaker's goal when speaking more languorously is not to reduce effort but instead to use the style of speaking appropriate to the circumstances" (3).

While an interpretation of articulatory undershoot as effort reduction has intuitive appeal, it remains unclear whether such tiny differences really matter and whether speakers really do undershoot a specified constriction target within a given time period instead of just choosing a shorter movement target to begin with.

A third argument against the effort-based approach has to do with the purported effects of flanking segments on consonant lenition. Based on a typological survey of descriptive grammars, Kirchner (1998: 189, 197) proposes the generalization in (14), where X and X' refer to segments situated along the aperture ranking in (15). (The ellipsis indicates that cross-linguistically, geminates never undergo partial reduction.)

(14) *The Aperture Conditioning Generalization*

Ceteris paribus, if a consonant C lenites when preceding (or following) X, and X' has aperture greater than or equal to X, then C lenites, to the same extent or to a greater extent, when preceding (or following) X' as well.

(15) low vowels > mid vowels > high vowels > liquids > glides > nasals > stops > strident fricatives > . . . > full or partial geminates

The generalization captures the observation that the aperture of flanking segments may determine the context of lenition as well as the degree to which target segments undergo gradient reduction. Some of the data cited in support of gradient aperture conditioning in consonant lenition come from Spanish. For example, Romero's (1996) articulatory study of Andalusian Spanish motivates the ranking of low above mid vowels in the aperture hierarchy. Evidence from electromagnetic midsagittal articulometry shows that speakers tend to produce a more reduced constriction degree for voiced stops /b, d, g/ in the context /a_e/ than in /e_e/. Kirchner attributes the asymmetry to the fact that a preceding low vowel is more open than a mid front vowel, leading to more extreme lenition of the following voiced stop. Kirchner argues that low vowels have greater aperture than high vowels comes because in some Spanish varieties, /d/ undergoes greater reduction in the past participle suffix /-ado/ than /-ido/, i.e. [ao] or [aw] vs. [iðo] or [ið̞o] (Resnick, 1975; also see Bybee, 2001 for New Mexican Spanish). Beyond the three degrees of vowel height, the rest of the aperture ranking in (15) is motivated by positional asymmetries among spirantization contexts in other languages, as well as by phonetic studies of jaw movement. However, Kingston (2008: 3-8) reviews the descriptive sources that form the basis of Kirchner's typology and concludes that gradient aperture conditioning is merely apparent. In many cases, the original descriptions and data turn out to be ambiguous. It turns out that the examples of postvocalic lenition marshalled from Southern Sotho, Chitwan Tharu, Yakut, Mbabaram, and Korean do not provide incontrovertible evidence that vowel height gradiently conditions the weakening of an adjacent consonant. In other cases, alternative explanations are available. For example, the difference in /d/-reduction between Spanish past participles "is just as likely to be a product of *-ado*'s greater frequency as its more open vowel: *-ado* occurs 1.75 times as often as *-ido* in the LexEsp corpus (Sebastián, Cuetos, Martí and Carreiras, 2000)" (Kingston, 2008: 8). Although Romero's (1996) Andalusian Spanish participants might display phonetic tendencies suggestive of aperture-conditioned lenition, Kingston argues against proposals to incorporate a continuous, physical scale of articulatory effort into grammars whose primitives are discrete categories. Rather, "a speaker selects an articulatory target which will produce the set of acoustic properties that will in turn convey whatever phonological information the speaker wishes to transmit at that moment in the utterance" (26, Fn. 23). When speakers lenite, they do not deliberately undershoot a constriction target that requires greater displacement. Rather, they select a closer target to begin with and then move the active articulator efficiently, with the shortest possible movement.

Even more devastating for the generalization in (14) is Kingston's claim that, cross-linguistically, consonants should be more likely than vowels to condition the reduction of an adjacent target consonant. The empirical basis of this claim comes from Parker's (2002) study of the phonetic correlates of sonority in North American English and Colombian Spanish consonants and vowels. The Spanish data are from eight speakers (four male, four female, mean age of 30 years) born and raised in highland Colombia, which means that Parker's findings are directly relevant to the present study of Colombian heritage Spanish in the U.S. Table 4.1 ranks the mean intensity values from highest to lowest for vowels and onset consonants as pronounced by Parker's female participants.[4] The means were calculated by subtracting the minimum dB of a reference consonant, /n/, from the minimum dB of the target consonant, or from the maximum dB of the target vowel. Positive values denote consonants of greater intensity relative to the nasal, and

[4] The sonority indices are theoretical values that Parker proposes for the purpose of establishing cross-linguistic correlations and statistical comparisons with other phonetic correlates, which are not relevant to the present discussion.

negative values, lesser intensity. The differences between each adjacent intensity mean in the ranking are statistically significant except in two cases: (i) between the lateral liquid [l] and the labiovelar glide [w] and (ii) between voiced stops [b, d, g] and their approximant allophones [β̞, ð̞, ɣ̞]. Parker's methodology does not attempt to distinguish between degrees of articulatory openness (i.e. pure vs. tense) in the approximant allophones (see Section 4.5 for more discussion). Furthermore, a noncontinuant pronunciation was consistently observed in the case of the voiced palatal affricate [ɟ͡ʝ̞], which ranks just below the voiced stops [b, d, g].

Table 4.1 Mean intensity values for vowels and onset consonants in Colombian Spanish

segments	sonority index	mean intensity in dB	
e, o	11	15.81	
a	12	14.85	
i, u	10	13.99	
w	9	10.83	} ns
l	8	9.04	
ɾ	7	6.33	
r	6	2.92	
m, n, ɲ	5	–.50	
β̞, ð̞, ɣ̞	4	–2.62	} ns
b, d, g	3	–4.03	
ɟ͡ʝ̞		–5.75	
h		–8.17	
f, s	2	–10.70	
p, t, k, ʧ	1	–12.07	

(based on Parker, 2002: 210)

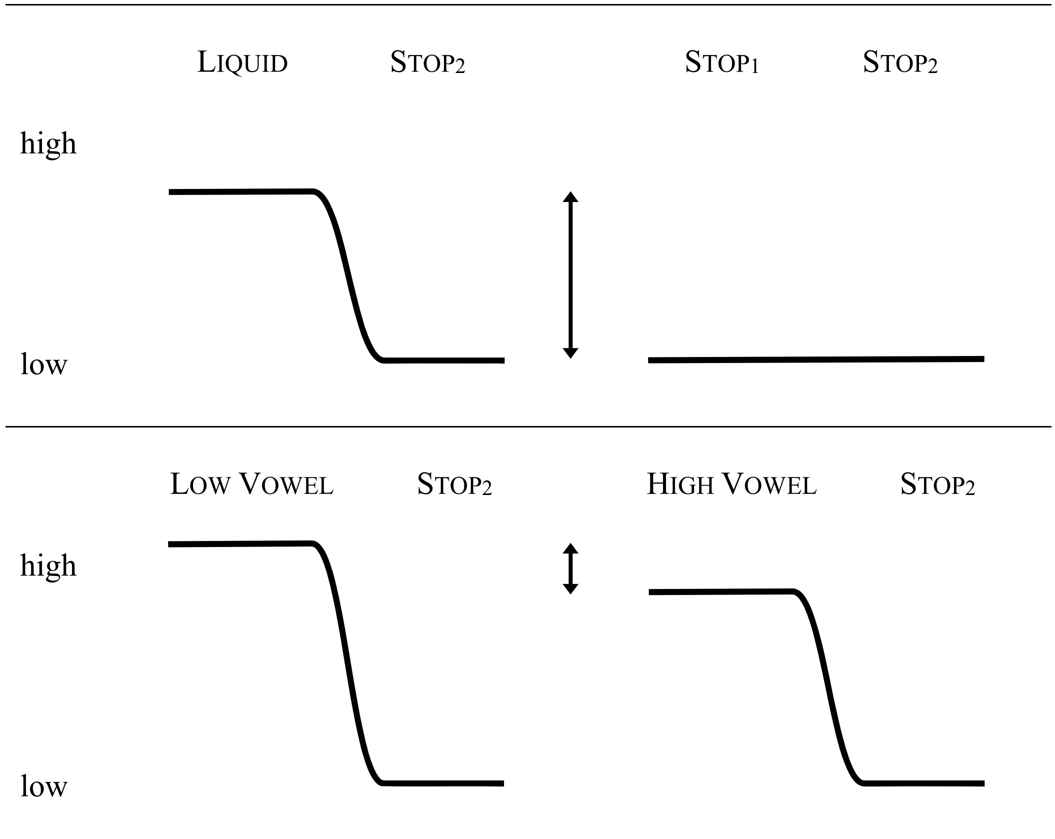
Kingston's argument rests on the observation that intensity differences show a much wider spread for consonants than for vowels. The difference between the most constricted consonants /p, t, k, ʧ/ (–12.07 dB) and the least constricted consonant /l/ (9.04 dB) is 21.11 dB. The difference for vocoids is much lower if the labiovelar glide /w/ is included, 15.81 dB (/e, o/) –

10.83 dB (/w/) = 4.98 dB, and even lower if only the full vowels are considered, 15.81 dB (/e, o/) − 13.99 dB (/i, u/) = 1.82 dB. A similar discrepancy between vocoids and consonants is found in Parker's North American English intensity data. Because the overall range of intensity values in these two languages is much smaller for vowels than for consonants, the prediction is that consonants should be more likely than vowels to condition the weakening of an adjacent target consonant. Kingston reasons as follows:

> "The large range of consonant intensities shows that increasing a consonant's openness by leniting it can therefore increase its intensity dramatically. On the one hand, leniting a consonant next to one whose constriction is itself relatively open would dramatically reduce the drop in intensity, while failing to lenite a consonant next to one whose constriction is instead relatively close would sustain the large drop in intensity. On the other hand, leniting a consonant next to a more open vowel would reduce the intensity drop little more than next to a closer vowel" (15).

Figure 4.1 provides a visual illustration of this argument. Each quadrant of the figure shows a stop consonant, labeled STOP$_2$, in a different segmental context: after a liquid consonant, another stop consonant, a low vowel, and a high vowel. Black lines represent hypothetical intensity contours that span across each bisegmental sequence. Up-down arrows indicate the difference between LIQUID and STOP$_1$ (top row) and between LOW VOWEL and HIGH VOWEL (bottom row). The crucial comparisons are between the left-hand segments in the top and bottom rows of the figure. As indicated by the corresponding up-down arrows, the intensity difference between the LIQUID on the left side of the figure and STOP$_1$ on the right side is much greater than between the LOW and HIGH VOWELS. If it were true that more open segments condition greater undershoot of the following STOP$_2$, then this effect should be greater and more common for preceding consonants than for preceding vowels, since consonants cover a wider range of possible degrees of openness than vowels do.

Figure 4.1 Segmental intensity differences in four contexts



Kingston reviews patterns of spirantization from Tümpisa Shoshone, Lowland Murut, Florentine Italian, and Koromfe (2008: 9-11), in which lenition applies next to vowels but is also more likely to apply next to more open consonants, except nasals. These languages appear to impose different cutoff points for triggering spirantization, based on the intensity of the adjacent consonant. As explained above, there is little cross-linguistic evidence to support to claim that spirantization is more likely to apply next to more open vowels. Together, these data suggest that while differences in consonant aperture can be phonologized as thresholds that condition the weakening of an adjacent consonant, the differences in vowel aperture cannot, simply because they are too small to matter in this respect.

We would like to highlight another aspect of Parker's intensity measurement data that is problematic for a theory of gradient aperture conditioning. The mean intensity values for the Colombian Spanish vowels in Table 4.1 show an unexpected sonority reversal, whereby the most sonorous low vowel /a/ turns out to have significantly less intensity than the mid vowels /e/ and /o/, 14.85 dB < 15.81 dB. The same reversal is also found in the vowel intensity measurements from Parker's four male speakers of Colombian Spanish.[5] If indeed a segment's acoustic intensity is positively correlated with its degree of articulatory openness, then we would expect the more open low vowel to have greater intensity than the less open mid vowels. The reversal in Colombian Spanish vowels instead predicts, paradoxically, that consonants should be more likely to lenite after a mid vowel than after a low vowel. This prediction goes against Kirchner's interpretation of Romero's (1996) articulatory data from Andalusian Spanish in which voiced stops are more reduced after a low vowel than a front mid vowel. It also goes against the notion of gradient aperture conditioning more generally, which predicts greater likelihood and degree of lenition in contact with more open vowels cross-linguistically.

Kingston's final argument against the functional role of effort reduction is that lenition is intimately connected with the opposite process of fortition in such a way as to suggest that both processes are ultimately driven by perceptual factors, based not on the speaker but on the listener. An overview of articulatory studies of domain-initial strengthening in various languages is

[5] Parker (2002: 121-122) finds even more surprising sonority reversals in the group means for North American English vowels: "low vowels have the lowest intensity, then mid vowels, and high vowels are the loudest," although differences as a function of vowel height are very small and not statistically significant.

presented by Keating (2006), who argues that consonant fortition "is cumulative, in the sense that the higher in the prosodic tree an initial position is, the stronger that position and the segment in it" (171). Greater strength is generally manifested through an increase in the degree and/or duration of linguopalatal contact, as measured by electropalatography, although the specific effects may vary depending on the language and the manner of articulation of the target consonant. Keating speculates that the functional basis of domain-initial strengthening may be to signal the degree of cohesion between words in connected speech. She argues that

> "while stronger segments may consume more calories of a speaker's articulatory energy than do weaker ones, weaker segments do not reflect laziness or inattention on the part of the speaker. Rather, we should think of the speaker's energy as constantly directed to control of the modulation of articulation, because all levels of strength carry information. To be sure, there is a general tendency in speaking towards ease of articulation, which is resisted in strong positions; and as a result, segmental cues may be weaker in weak positions. […] But then this reduction in segmental information is itself information for listeners—information about juncture" (180).

Kingston agrees with Keating and argues for an explicit link between lenition and fortition, which function as complementary processes within a given prosodic domain. Acknowledging this link helps reveal the overarching motivation of both processes.

> "If lenition reduces the interruption of the stream of high intensity intervals caused by the affected consonant, then it may convey to the listener that the current prosodic constituent is continuing rather than a new one beginning. Lenition would thereby complement the strengthening of segments at the edges of prosodic

> constituents […], which interrupts that stream of high intensity events more and in doing so signals to the listener that a new prosodic constituent is beginning rather than the old one continuing. In this interpretation, lenition, like strengthening, has a communicative purpose, to convey information to the listener about the prosodic grouping of strings. This purpose can only be achieved when susceptible sounds occur at potential prosodic edges, but this opportunism in no way diminishes the communicative value of these changes in pronunciation, when they occur" (Kingston 2008: 16).

Weakening a consonant increases its intensity relative to the surrounding vowels, while strengthening a consonant decreases its intensity. The idea is that speakers use these opposite effects jointly to signal the location of prosodic boundaries to listeners.

Kingston presents experimental evidence from Spanish in support of the claim that prosodic structure mediates consonant strength, based on a production study of consonant intensity with two female speakers, one from Ecuador and the other from Peru. The participants read randomized carrier phrases containing test words with initial voiced and voiceless stops in different segmental and prosodic contexts. Independent variables included the preceding segment (vowel or nasal), the syntactic/prosodic distance of the preceding word (auxiliary verb, short subject, long subject, or subordinate clause), the height of the preceding vowel (low, mid, or high), and the voicing status and place of articulation of the target consonant. Dependent variables included the minimum dB closest to the constriction's beginning and the maximum dB closest to its end, as measured across several frequency bands. Results show that the place of articulation of a stop has no significant effect on its weakening. Curiously, stops are found to be *more* lenited next to higher than lower vowels. This is unexpected based on the aperture ranking in (15) and further problematizes the predictions of gradient aperture conditioning, as does the reversal between Colombian Spanish low and mid vowels shown in Table 4.1. Kingston finds that "stops lenite less after nasals than vowels and when voiceless than voiced. They also lenite less when the preceding word is farther away syntactically and prosodically" (25). The failure to spirantize after nasals can be understood as an instance of post-nasal hardening, motivated by articulatory or aerodynamic constraints based on speech production. However, articulatory factors alone cannot explain the functional linkage between lenition and fortition and the sensitivity of both processes to prosodic structure:

> "Effort reduction fails to capture what determines a speaker's behavior because it is an account of only an early step in the speech chain, and not the entire event. Reducing the interruption of the stream of high intensity sounds by increasing a consonant's intensity is instead an account of the entire event: a more open articulation is chosen to increase acoustic intensity, reduce interruption, and thereby convey that the current prosodic constituent is continuing rather than a new one beginning" (27).

Prosodic structure mediates domain-medial consonant lenition and domain-initial consonant fortition in the following manner: speakers employ both processes to help listeners parse the speech stream and recover the prosodic grouping of the speaker's intended utterance.[6]

Recent psycholinguistic studies have provided the first experimental confirmations that listeners' perception of word boundaries is facilitated by the spirantization alternation. Katz and Fricke (2018) used an artificial language learning and word segmentation paradigm with 90 young

[6] In independent work, Harris (2003) proposes a view of lenition similar to that of Kingston (2008), based on the claim that domain-medial lenition renders the target consonant more similar to flanking segments.

adult native listeners of American English, enrolled as undergraduates at UC Berkeley. They found that participants who had learned the spirantization pattern of initial stops vs. medial continuants were subsequently better at segmenting new words in the artificial language than participants who had learned the anti-spirantization pattern of initial continuants vs. medial stops. This result shows that listeners make use of spirantization to infer the location of prosodic boundaries in novel linguistic items, even when their language lacks a systemic process of spirantization. In a follow-up study, Katz and Moore (2021) replicate the findings of Katz and Fricke (2018) on a smaller group of 36 young adult native listeners of American English, enrolled as undergraduates at West Virginia University. However, this second study failed to find any significant results with 22 children enrolled in area elementary schools. In fact, the youngest participants showed minimal statistical learning effects and much greater variability than the young adults in general using the same experimental paradigm.

4.4 Phonological contrast, continuity lenition, and boundary disruption

To summarize the discussion thus far, lenition phenomena do reflect phonetic tendencies toward less effortful articulations, but these articulatory factors are unlikely to be phonologized. Rather, the speaker's grammar uses abstract phonetic knowledge about relative segmental intensity to ensure that disruptions in intensity are optimally distributed so as to facilitate the listener's perception of prosodic constituent boundaries. On this view, both fortition and lenition are driven primarily by the perceptual needs of the listener.

Nevertheless, it is important to recognize that not all lenition processes complement fortition in this way. Katz (2016) distinguishes two types of consonant weakening, *loss lenition* and *continuity lenition,* and argues that only the latter type is linked to fortition in the manner proposed by Keating (2006) and Kingston (2008). Loss lenition entails the removal of a feature or segment from the phonological representation, tends to apply in contexts of diminished perceptibility, and may neutralize phonological contrasts. Examples of loss lenition include consonant degemination (e.g. /pp/ → [p]) and debuccalization (e.g. /p/ → [ʔ], [h], [Ø]). An example of positional neutralization is when stops contrasting in place of articulation are debuccalized in coda position, e.g. /p/, /t/, /k/ → [ʔ]. On the other hand, continuity lenition entails an increase in consonant intensity and/or duration, tends to apply in perceptually prominent positions, such as between vowels, and does not typically neutralize phonological contrasts. Examples include intervocalic voicing (e.g. /p/ → [b]) and spirantization (e.g. /p/ → [ɸ], /b/ → [β]). In Spanish, the alternation between voiced stops and continuants is completely allophonic and does not involve positional neutralization. The language has no phonological continuancy contrast within the class of voiced obstruents, which means that /b, d, g/ and /β, ð, ɣ/ are not separate phonemes in Spanish. Conjointly with fortition, processes classified as continuity lenition result in a distribution of weaker allophones within prosodic domains and stronger allophones at domain edges. This segmental pattern serves to convey information to the listener about the prosodic structure of the utterance. Katz (2016) explains the connection between medial lenition and initial fortition as follows:

> "Intervocalic voicing and spirantization can thus be characterized as rendering consonants more similar to surrounding vowels in terms of intensity, and therefore less disruptive in the context of those vowels. Fortifying or failing to lenite at the beginning or end of a constituent will render consonants in these positions less like vowels in terms of intensity than their lenited counterparts would be, and thus more disruptive. This is the source of the term 'continuity lenition' proposed in this

> paper: these types of lenition are primarily organized to preserve auditory continuity within prosodic constituents.
>
> The motivation behind this pattern is that it aligns auditory disruptions with constituent boundaries, and lack of disruption with lack of boundaries, which plausibly helps a listener detect where the boundaries are" (47).

Katz's theory of boundary disruption provides a more complete understanding of the listener-based motivation driving allophonic lenition and fortition. Attempts to explain lenition in terms of effort reduction alone do not take the role of the listener into account and thereby miss the bigger picture.

Katz (2016: 49) proposes two diagnostics for knowing whether a consonantal weakening process qualifies as continuity lenition: (i) it usually targets intervocalic consonants, although it may also target non-intervocalic domain-medial consonants, and (ii) it makes the intensity and/or duration of domain-medial consonants less disruptive compared to the high-energy backdrop of the flanking vowels. As a prime example of continuity lenition, he describes the spirantization of voiced stops in Spanish, based on phonetic transcriptions of two speakers from Venezuela, and cites similar patterns in Ondarroan Basque, Kinande, Badimaya, Sina, and Japanese. Cross-linguistically, spirantization "is most frequently observed between vowels and sonorant consonants, less frequently in medial clusters and final position, and is often blocked following nasals. It rarely results in positional neutralization of contrasts found elsewhere in a language" (Katz, 2016: 51).[7]

[7] Katz (2016) also examines voicing lenition in Sanuma, Urubu-Kaapor, and Chungli Ao, in which initial voiceless stops alternate with medial voiced ones. We will not discuss voicing lenition in great detail here, since we are concerned primarily with spirantization.

To explain why word-medial spirantization and voicing are allophonic processes that do not lead to the positional neutralization of contrasts, Katz argues that continuity lenition and loss lenition must be given distinct formal treatments in OT.[8] The positional neutralizations caused by loss lenition, as in degemination and debuccalization, can be modeled as the interaction of markedness and faithfulness constraints, in which one or the other constraint family makes reference to positions of relative strength or weakness along some implicational hierarchy. On the other hand, continuity lenition must be formalized as the interaction between faithfulness constraints and *a single markedness constraint that is responsible for both lenition and fortition.* This restriction limits the formal analysis of phonological contrast to just two degrees of freedom, contrast in neither position or contrast in both, as illustrated by the toy grammars in (16) and (17), respectively. The label LENITIONFORTITION is a temporary stand-in for a family of markedness constraints to be defined more precisely below. IDENT(F) is a type of faithfulness constraint that requires identical values of the feature F in two corresponding segments (McCarthy and Prince, 1999: 226). In this case, one segment is in the input and the other in the output; the phonological feature is [continuant], which distinguishes between the natural classes of stops vs. continuants. For the moment, we simplify most of the presentation by using the symbol [β] as a broad representation of voiced continuants, without distinguishing among different degrees of openness or frication noise (cf. Section 4.5). When markedness dominates faithfulness, the distribution of voiced stops and continuants is completely predictable and non-contrastive. The potential input

[8] We assume that readers have a basic understanding of surface-oriented, constraint-based phonology. For detailed introductions to OT, Archangeli and Langendoen (1997), Kager (1999), Prince and Smolensky (2004), McCarthy (2002), and McCarthy and Prince (1999). On the phonology of Spanish from OT perspectives, see Bradley (2014), Colina (2009, 2014), Martínez-Gil and Colina (2006), and Torres-Tamarit (2020).

contrast between /b/ and /β/ is neutralized in the output, which shows a complementary distribution between initial [b] (16)a,c and medial [β] (16)f,h.

(16)

	LENITIONFORTITION	IDENT(continuant)
☞ a. /ba/ → ba		
b. βa	*!	*
☞ c. /βa/ → ba		*
d. βa	*!	
e. /aba/ → aba	*!	
☞ f. aβa		*
g. /aβa/ → aba	*!	*
☞ h. aβa		

This analysis is entirely consistent with the OT tenet known as Richness of The Base (ROTB), which states that generalizations about a language's inventory of sounds in the output must emerge from the phonological grammar (i.e. constraint ranking) and not from any restrictions placed directly on the input, nor from some combination of input restriction and phonological operation or constraint (Prince & Smolensky, 2004: 205, 225; McCarthy, 2002: 70-71, 2008: 88-95). Even if voiced obstruents do not contrast for continuancy in some language, the analysis must assume such contrasts to be present in the input, at least theoretically, in order to show how they would be neutralized by the phonological grammar in the output. LENITIONFORTITION ensures neutralization by strengthening input /β/ to [b] in initial position (16)c but by weakening input /b/ to [β] in medial position (16)f.

Under the opposite ranking of faithfulness above markedness, the stop-continuant distribution is contrastive in both initial and medial positions. High ranking IDENT(continuant) forces the value for that feature in an input segment to surface faithfully in that segment's output correspondent, resulting in a surface contrast between [b] and [β] in both initial (17)a,d and medial (17)e,h positions.

(17)

		IDENT(continuant)	LENITIONFORTITION
☞	a. /ba/ → ba		
	b. βa	*!	*
	c. /βa/ → ba	*!	
☞	d. βa		*
☞	e. /aba/ → aba		*
	f. aβa	*!	
	g. /aβa/ → aba	*!	*
☞	h. aβa		

Crucially, a [b]-[β] contrast in initial position entails a [b]-[β] contrast in medial position, and *vice versa.* Positional neutralization, i.e. in just one of the two contexts, is correctly ruled out because there is only one markedness constraint that assigns different violations to two complement sets of output candidates: the initial continuants in candidates (b,d) vs. the medial stops in candidates (e,g). If, instead, separate markedness constraints were responsible for assigning violations in each position, then it would become possible to rank faithfulness in between the two, thereby overpredicting positional neutralization. Katz (2016: 53-54) shows how this problem arises in an analysis of the complementary distribution between medial voiced stops and initial voiceless stops. Continuing with our example of spirantization from above, tableau (18) illustrates the problem of splitting LENITIONFORTITION into separate constraints, one against intervocalic [b] and the other against postpausal [β]. Under the ranking shown here, the [b]-[β] contrast is maintained in initial position (18)a,d but neutralized to [β] in medial position (18)f,h.

We leave it to the reader to confirm that the opposite ranking of FORTITION above LENITION also incorrectly predicts positional neutralization but, in this case, to [b] in initial position (18)a,c.

(18)

	LENITION	IDENT(continuant)	FORTITION
☞ a. /ba/ → ba			
b. βa		*!	*
c. /βa/ → ba		*!	
☞ d. βa			*
e. /aba/ → aba	*!		
☞ f. aβa		*	
g. /aβa/ → aba	*!	*	
☞ h. aβa			

In Section 1.5.3 of Chapter 1, we noted that Cabrelli Amaro's (2017) OT analysis of L2 Spanish spirantization does not respect ROTB. Because the faithfulness constraints IDENT(continuant) ONSET PW and IDENT(continuant) ONSET SYLL are responsible for blocking spirantization, the analysis works only if voiced stops are stipulated in the input. Tableau (19) shows what happens once both stops and approximants are considered as possible inputs to the beginning L2 grammar. *VOICED STOP/V_ predicts positional neutralization to approximants in word-medial intervocalic position (19)b,d, but higher ranking IDENT(continuant) ONSET PW predicts a continuancy contrast in word-initial intervocalic position (19)e,h. This is the same problematic pattern of neutralization illustrated in (18) that Katz (2016) warns about, but generated by positional faithfulness constraints instead of positional markedness.

(19)

Beginning L2 learners (assuming ROTB)	IDENT(continuant) ONSET PW	*VOICED STOP/V_	IDENT(continuant) ONSET SYLL	IDENT(continuant)	*APPROXIMANT/V_
a. /duda/ → ˈdu.da		*!			
☞ b. ˈdu.ð̞a			*	*	*
c. /duð̞a/ → ˈdu.da		*!	*	*	
☞ d. ˈdu.ð̞a					*
☞ e. /ʧika dudosa/ → ˈʧi.ka duˈ.ð̞o.sa		*			*
f. ˈʧi.ka ð̞uˈ.ð̞o.sa	*!		*	*	**
g. /ʧika ð̞udosa/ → ˈʧi.ka duˈ.ð̞o.sa	*!	*	*	*	*
☞ h. ˈʧi.ka ð̞uˈ.ð̞o.sa					**

From a formal perspective, continuity lenition is special because it requires the constraints abbreviated as LENITION and FORTITION to function as a single, unitary markedness constraint in the grammar. Katz proposes a new family of BOUNDARY-DISRUPTION constraints that have exactly this property. Each such constraint enforces opposite requirements in complementary positions, depending on whether the target segment appears inside a given prosodic domain or at the edges, for the purpose of increasing the perceptibility of domain boundaries. "If phonetic realization is predictable from prosodic position, and *vice versa,* it is possible to identify prosodic units through their phonetic properties" (55). Katz (2016: 56) defines a constraint schema that makes reference to three scalar parameters, i.e. intensity, duration, and prosodic boundary level:

(20) BOUNDARY-DISRUPTION(*I,D,P*)

Intensity drops to amount *I* or lower for at least duration *D at and only at* a prosodic boundary of level *P*.

The markedness schema in (20) is defined in positive terms, stating properties that must be present in the output. In our experience, however, assigning violations to candidates based on this positive formulation is not a straightforward task when working with multiple intensity levels and prosodic domains. A further complication arises in the interpretation of the phrase *"at and only at,"* which is intended to capture the disjunction between edge-adjacent and non-edge-adjacent (i.e. medial) positions. We propose to reformulate Katz's original schema, in accordance with McCarthy's (2003) convention of defining categorical markedness constraints, by explicitly stating the conditions that must hold of a given locus of violation within the output candidate in order for a violation to be triggered. Our definition reads more like an explicit instruction that follows the template, "Assign a violation for every consonant that is X but is not Y." This makes it possible to tease apart the disjunction into two separate statements that differ solely in the relative ordering of X and Y:

(21) BOUNDARY-DISRUPTION(*I,D,P*)

Assign a violation for every consonant that

a. is of intensity $\leq I$ and duration $\geq D$ but is not at a prosodic boundary of level *P*

b. is at a prosodic boundary of level *P* but is not of intensity $\leq I$ and duration $\geq D$.

The first statement (21)a targets any consonant of intensity *I* or lower, and duration *D* or longer, that is not aligned with a prosodic boundary of level *P*. The second statement (21)b targets any consonant that is aligned with a prosodic boundary of level *P* but is not of intensity *I* or lower and duration *D* or longer. The dual functions of the stand-in constraint LENITIONFORTITION used in (16) and (17) are captured by the combined action of (21)a, which favors continuity lenition in non-edge positions, and (21)b, which favors fortition at domain edges.

Markedness constraints of the BOUNDARY-DISRUPTION family are phonetically grounded in the perceptibility of auditory disruption at different prosodic boundaries. Katz hypothesizes the disruption indices in Table 4.2 based on well motivated values of intensity and duration. For example, Parker's (2002) intensity ranking in Table 4.1 follows a broadly similar relative ordering of segments, and voiceless obstruents are known to be phonetically longer than their voiced counterparts (Lavoie, 2001). The scale in Table 4.2 ranks consonant classes by the degree to which they disrupt the stream of the surrounding vowels of even greater intensity (not shown here).

Table 4.2 Hypothesized disruption indices for major consonant classes

class		intensity	duration
J	glide	6	2
R	tap	5	1
Z	voiced continuant	4	2
D	voiced stop	3	2
S	voiceless continuant	2	3
T	voiceless stop	1	3

(based on Katz, 2016: 57)

Intensity contours can be represented quantitatively by converting segmental strings into numerical sequences. Assuming vowels to have an intensity index of 7, we propose the continuum in Figure 4.2, in which progressively flatter [VCV] contours appear to the left. Intensity indices appear below corresponding segments. A glide (J) is the least disruptive, dropping intensity by just 1 level in 767. At the other end of the continuum, a voiceless stop (T) is the most disruptive, dropping intensity by 6 levels in 717. According to our revised definition of BOUNDARY-DISRUPTION, (21)a raises consonantal intensity and produces a flatter intensity contour in [VCV] sequences in the absence of a specified prosodic boundary, while (21)b lowers the intensity index of consonants and renders them more disruptive between vowels when such a boundary is present.

Figure 4.2 Ranking of [VCV] intensity contours by relative flatness

VJV	VRV	VZV	VDV	VSV	VTV
767	757	747	737	727	717

continuity lenition *less disruptive C* *flatter contour*	*fortition* *more disruptive C* *less flat contour*

The third scalar parameter to which BOUNDARY-DISRUPTION constraints refer is prosodic boundary level. Figure 4.3 displays the entire range of prosodic constituents that we assume here. The prosodic hierarchy is governed by the Strict Layer Hypothesis (Selkirk, 1986), such that lower constituents must be contained by the next highest constituent, and levels may not be skipped over or repeated. Earlier proposals in the literature included a clitic group between the prosodic word and the phonological phrase. We assume instead, following Itô and Mester (2007, 2009a,b,), that recursion of constituents is possible and that any clitics or unstressed function words, such as definite articles, prepositions, conjunctions, etc., are recursively adjoined to the prosodic word. The bottom and topmost projections of the prosodic word are subscripted as ω_{min} and ω_{max}, respectively, with intermediate projects (if any) in between.

Figure 4.3 Domains of the prosodic hierarchy

Utterance	U
Intonational Phrase	ι
Phonological Phrase	φ
Maximal Prosodic Word	ω_{max}
(Intermediate Prosodic Words	ω)
Minimal Prosodic Word	ω_{min}
Foot	Σ
Syllable	σ

(adapted from Bonet, 2020: 333; also see Selkirk, 1978, 1984, 1986; Nespor & Vogel, 1986)

Another special property of Boundary-Disruption is that constraint violations can be triggered by ranges of segments that fail to meet a disruption threshold. To understand how this works, it is helpful to see how several constraints assign violations to output candidates, first by holding prosodic domain constant while varying intensity, and then by holding intensity constant while varying prosodic domain. The general schema in (21) projects specific Boundary-Disruption constraints that combine the intensity indices of Table 4.2 with the prosodic boundary levels of Figure 4.3. The 24 constraints in (22) show theoretically possible combinations of six intensity levels with four prosodic boundary levels, ranging from the foot to the phonological phrase. The duration parameter is set to 0 because consonantal duration is hypothesized to be relevant primarily for voicing lenition alternations (see Katz, 2016: 64-66 on Chungli Ao) but not for spirantization. A null duration value means that a consonant with the specified intensity level or lower, held for *any amount of time,* will either satisfy the constraint if aligned with the specified prosodic boundary or violate the constraint if not aligned with the boundary. These constraints may be read aloud simply as "BD, one, phonological phrase," "BD, two, max word," "BD, three, foot," and so on.

(22)	BD(1,0,φ)	BD(1,0,ω_{max})	BD(1,0,ω_{min})	BD(1,0,Σ)
	BD(2,0,φ)	BD(2,0,ω_{max})	BD(2,0,ω_{min})	BD(2,0,Σ)
	BD(3,0,φ)	BD(3,0,ω_{max})	BD(3,0,ω_{min})	BD(3,0,Σ)
	BD(4,0,φ)	BD(4,0,ω_{max})	BD(4,0,ω_{min})	BD(4,0,Σ)
	BD(5,0,φ)	BD(5,0,ω_{max})	BD(5,0,ω_{min})	BD(5,0,Σ)
	BD(6,0,φ)	BD(6,0,ω_{max})	BD(6,0,ω_{min})	BD(6,0,Σ)

The first four constraints of the second column in (22) are illustrated in quasi-tableaux (23) and (24). These are not complete tableaux because they omit inputs, faithfulness constraints, fatal constraint violations, and optimal candidates. Their purpose is simply to illustrate relationships among the violation marks that are assigned by BOUNDARY-DISRUPTION constraints. Abbreviated as BD, these constraints make reference to intensity levels 1 through 4 and are all relativized to the maximal prosodic word boundary level. The broken lines between constraint columns indicate that the constraints are not crucially ranked with respect to each other (see the discussion surrounding Table 4.3).

(23)

	BD $(1,0,\omega_{max})$	BD $(2,0,\omega_{max})$	BD $(3,0,\omega_{max})$	BD $(4,0,\omega_{max})$
a. $(apa)\omega_{max}$ 717	*	*	*	*
b. $(a\phi a)\omega_{max}$ 727		*	*	*
c. $(aba)\omega_{max}$ 737			*	*
d. $(a\beta a)\omega_{max}$ 747				*

(24)

	BD $(1,0,\omega_{max})$	BD $(2,0,\omega_{max})$	BD $(3,0,\omega_{max})$	BD $(4,0,\omega_{max})$
a. $a(pa)\omega_{max}$ 7 17				
b. $a(\phi a)\omega_{max}$ 7 27	*			
c. $a(ba)\omega_{max}$ 7 37	*	*		
d. $a(\beta a)\omega_{max}$ 7 47	*	*	*	

Expanding upon the toy candidate set from (16) and (17), the outputs show four types of intervocalic consonant in medial (23) and initial (24) positions of the maximal prosodic word domain: a voiceless stop (a), voiceless continuant (b), voiced stop (c), and voiced continuant (d). As indicated by the intensity contours beneath each candidate, these segmental strings correspond to the four rightmost [VCV] contours on the continuum in Figure 4.2. Although the constraints have no universally fixed ranking, it is helpful to order them so that the intensity parameter increases from left to right. BD$(1,0,\omega_{max})$ assigns a single violation to (23)a because, although [p] causes a drop in intensity to level 1 between vowels, this drop is not aligned with a maximal prosodic word boundary. On the other hand, BD$(1,0,\omega)$ is vacuously satisfied by (23)b-d because [ɸ], [b], and [β] do not cause a drop in intensity to level 1. In domain-medial position, BD(1,0,ω_{max}) cares only about avoiding consonants whose intensity index is 1, and any competing consonant of higher intensity will do. In domain-initial position, however, the effects of BD(1,0,ω_{max}) are reversed. The consonants in (24)b-d are not disruptive enough to be aligned with a maximal prosodic word boundary, so only (24)a will do. Thus, BD(1,0,ω_{max}) assigns violations to an entire range of candidates (24)b-d whose intervocalic consonants are aligned with the maximal prosodic word boundary but fail to meet the specified intensity threshold.

Moving from left to right across both quasi-tableaux, we see a systematic transfer of violation marks, from the topmost cell of a given column in (24) to the bottommost cell of the next column in (23). The direction of transfer goes rightward across constraints from a lower to higher intensity level, and upward from the lower to the upper tableau. For example, the voiceless continuant [ɸ] is the lowest intensity consonant that violates BD(1,0,ω_{max}) in domain-initial position (24)b, and it is also the highest intensity consonant that violates BD(2,0,ω_{max}) in domain-medial position (23)b. Each pair of adjacent columns is characterized by the same trade-off relationship when the constraints are arranged in order of increasing intensity. A threshold of auditory disruption emerges from the overall pattern of violation marks, which form two right-angled triangles whose 90° angles occupy opposite quadrants of their respective tableau, i.e. the top right in (23) vs. the bottom left in (24). The hypotenuses of both triangles converge on what are the intensity cutoffs for medial vs. initial segments in the maximal prosodic word.

Violations of BOUNDARY-DISRUPTION constraints can be triggered by ranges of segments also as a function of prosodic position. To show this, we hold intensity constant while varying prosodic domain. The quasi-tableaux in (25) and (26) illustrate the four constraints of the third row in (22), which refer to intensity level 3 but are relativized to different prosodic boundary levels.[9] Again, the constraints are unranked but ordered for ease of illustration, this time so that the boundary level goes downward in the prosodic hierarchy as the columns go from left to right. In each quasi-tableau, the output candidates place the same intervocalic consonant—a voiced continuant in (25) vs. a voiced stop in (26)—in different prosodic positions: at the beginning of the phonological phrase (a), maximal prosodic word (b), minimal prosodic word (c), and the foot (d), as well as in medial position of the foot (e). The level of the prosodic boundary appearing before the target consonant correlates positively with the number of opening parentheses that intervene between the consonant and the preceding vowel, ranging from four in phrase-initial position (a) to just one at the left edge of the minimal prosodic word (d). There is no adjacent opening parenthesis in foot-medial position (e), as the target consonant is initial at only the syllable level (not indicated here). BD(3,0,φ) assigns a single violation to (25)a, because [β] is not disruptive enough to be aligned with a phonological phrase boundary, but is vacuously satisfied by (25)b-e because [β] is no longer at the phrase boundary.

[9] Recall that the purpose of a quasi-tableau is simply to illustrate relationships among assigned violation marks. In fact, tableaux (25) and (26) do not even make sense as legitimate candidate evaluations. The grammar selects the optimal degree of auditory disruption based on a given prosodic representation, not the optimal prosodic representation based on a given degree of auditory disruption.

(25)

	BD $(3,0,\varphi)$	BD $(3,0,\omega_{max})$	BD $(3,0,\omega_{min})$	BD $(3,0,\Sigma)$
a. $a((((\beta a)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 47	*	*	*	*
b. $(a(((\beta a)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 47		*	*	*
c. $((a((\beta a)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 47			*	*
d. $(((a(\beta a)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 47				*
e. $((((a\beta a)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 747				

(26)

	BD $(3,0,\varphi)$	BD $(3,0,\omega_{max})$	BD $(3,0,\omega_{min})$	BD $(3,0,\Sigma)$
a. $a((((ba)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 37				
b. $(a(((ba)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 37	*			
c. $((a((ba)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 37	*	*		
d. $(((a(ba)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 7 37	*	*	*	
e. $((((aba)_{\Sigma})_{\omega min})_{\omega max})_{\varphi}$ 737	*	*	*	*

With respect to the voiced stop candidates, BD$(3,0,\varphi)$ is satisfied by (26)a because phrase-initial [b] meets the intensity threshold of level 3. The same constraint assigns violations to the entire range of candidates (26)b-e whose intervocalic consonants *meet the specified intensity threshold but fail to align with the specified prosodic boundary*. It is informative to compare these violations to those in (24)b-d, which are assigned by BD$(1,0,\omega_{max})$ but for the inverse reason, i.e. the intervocalic consonants *are aligned with the specified prosodic boundary but fail to meet the* *specified intensity threshold.* Interestingly, although they are assigned for opposite reasons, the violation marks yield the same geometric pattern of two diametrically opposed right-angled triangles. The diagonal running from the top-left to the bottom-right establishes thresholds for consonantal intensity in (23) and (24) but for prosodic boundary level in (25) and (26).

BOUNDARY-DISRUPTION constraints are able to capture implicational relationships among the prosodic levels at which continuity lenition and fortition processes apply. Specifically, "if a boundary at some level triggers fortition, then all higher-level boundaries do as well; if lenition applies across a boundary at some level, then it applies across all lower levels" (Katz, 2016: 56). For example, the violation of BD(3,0,*Σ*) by [β] at the left edge of the foot (25)d entails a violation of the same constraint by [β] at the left edge of higher prosodic domains, i.e. the minimal prosodic word (25)c, maximal prosodic word (25)b, and phonological phrase (25)a. Similarly, the failure to align [b] with the phrase boundary (26)b triggers a violation of BD(3,0,*φ*), which entails a violation of the same constraint by phrase-medial [b] in the initial position of prosodic domains below the maximal prosodic word, i.e. the minimal prosodic word (26)c and the foot (26)d, as well as in foot-medial syllable-initial position (26)e.

In OT, constraints whose violation marks arrange themselves in triangular fashion within a quasi-tableau are said to form a *stringency hierarchy* (de Lacy 2004). Given a pair of constraints, the more general of the two is said to be the more stringent constraint because it assigns more violations to the same set of candidates than the more specific, less stringent constraint assigns. Violations of the more stringent constraint form a *superset* of, or contain, the violations of the less stringent constraint; conversely, violations of the less stringent constraint form a *subset* of, or are contained by, the violations of the more stringent constraint. As illustrated above, varying intensity while holding domain constant reveals superset-subset relationships but in opposite directions, depending on whether the target consonant is aligned with the specified prosodic boundary. In domain-medial position (23), the violation marks of BD(4,0,ω_{max}) contain all the violations of BD(3,0,ω_{max}), which contain all those of BD(2,0,ω_{max}), which contain the single violation of BD(1,0,ω_{max}). In domain-initial position (24), the violation marks for BD(1,0,ω_{max}) contain all the violations of BD(2,0,ω_{max}), which contains the single violation of BD(3,0,ω_{max}). BD(4,0,ω_{max}) assigns no violations to any of these candidates because they all have domain-initial consonants that meet the specified intensity threshold. When intensity is held constant while varying domain, similar superset-subset relationships emerge, again in opposite directions, but this time depending on whether the target consonant meets the specified intensity threshold. Given an intervocalic consonant of intensity level 4, as shown in (25), the violation marks of BD(3,0,Σ) contain all the violations of BD(3,0,ω_{min}), which contain all those of BD(3,0,ω_{max}), which contain the single violation of BD(3,0,φ). When the consonant is of intensity level 3, as shown in (26), the violations marks of BD(3,0,φ) contain all the violations of BD(3,0,ω_{max}), which contain all those of BD(3,0,ω_{min}), which contain the single violation of BD(3,0,Σ).

An important consequence of stringency is that the harmony, or relative well-formedness, of a given candidate can be calculated as a function of the number of total violations of the relevant constraints it incurs, i.e. by counting the number of violation marks in the candidate's row. The fewer the violations, the more harmonic the intensity contour. Table 4.3 lists the total constraint violations incurred by each of the four [VCV] intensity contours when the target consonant is medial (23) vs. initial (24) within the maximal prosodic word:

Table 4.3 Total violations of BOUNDARY-DISRUPTION constraints based on the cross-tabulation of prosodic positions by intensity contours

	aβa 747	aba 737	aɸa 727	apa 717
$(V\_V)\omega_{max}$	1	2	3	4
$V(\_V)\omega_{max}$	3	2	1	0

These totals define two harmony scales that go in opposite directions. In domain-medial position, 747 is the most harmonic, and 717, the least. In domain-initial position, 717 is the most harmonic, and 747, the least. For constraints that are in a stringency relationship, the harmony of each candidate remains the same no matter how the constraints are ranked with respect to each other. This is the reason why the BOUNDARY-DISRUPTION constraints in (23) through (26) are left unranked and their columns, separated by broken lines. A formal advantage of stringency is that it obviates the need to stipulate a universally fixed ranking for constraints that act together in an implicational fashion. Typological implications are already accounted for by the superset-subset relationships that exist among violation marks assigned by BOUNDARY-DISRUPTION constraints to output candidates. Threshold effects emerge from the way faithfulness constraints interact with BOUNDARY-DISRUPTION constraints, which need not be ranked among themselves.

With the theory of continuity lenition now in place, we show how BOUNDARY-DISRUPTION functions as a single, unitary markedness constraint in the grammar, thereby fulfilling the role of the stand-in constraint LENITIONFORTITION. The eight input-output mappings from tableau (16) are repeated in (27) but with prosodic structure and numerical intensity contours added to the output candidates:

(27)

	BD(3,0,φ)	IDENT(continuant)	BD(4,0,φ)
☞ a. /ba/ → (ba)φ 37			
b. (βa)φ 47	*!	*	
☞ c. /βa/ → (ba)φ 37		*	
d. (βa)φ 47	*!		
e. /aba/ → (aba)φ 737	*!		*
☞ f. (aβa)φ 747		*	*
g. /aβa/ → (aba)φ 737	*!	*	*
☞ h. (aβa)φ 747			*

Katz's (2016: 59-64) analysis of spirantization in Venezuelan Spanish posits that continuity lenition and fortition operate over the phonological phrase. In the theoretical literature on Spanish there is consensus that postvocalic lenition applies postlexically, both within words and across word boundaries, but there is actually disagreement over the prosodic domain of lenition within the utterance. Zampini (1997: 216) follows Nespor and Vogel (1986) in assuming that the relevant domain for monolingual general Spanish is the intonational phrase. More recently, Bonet (2020: 336-337) argues that postvocalic spirantization and regressive nasal place assimilation both apply at the level of the utterance, which is the highest domain of the prosodic hierarchy in Figure 4.3. In any event, determining the scope of continuity lenition at the highest levels of the hierarchy remains as a goal for future study, given the current study's focus on the relatively lower syllable, PW-max, and PW-min constituents. We adopt Katz's original constraint formulation motivated by his descriptions of two Venezuelan Spanish speakers, BD(3,0,φ), which refers to the phonological phrase, but with the caveat that the actual domain might be as extensive as the entire utterance.

One crucial ranking, BD(3,0,φ) » IDENT(continuant), is responsible for generating the allophonic pattern of phrase-initial voiced stops vs. phrase-medial voiced continuants. In particular, BD(3,0,φ) rules out (27)b,d because [β] is not disruptive enough at the phonological phrase boundary and also rules out (27)e,g because [b] is not aligned with a phrase boundary, despite being sufficiently disruptive. BD(4,0,φ) is included just for illustration; its ranking with respect to the other two constraints does not change the outcome. However, the opposite ranking of IDENT(continuant) » BD(3,0,φ) would predict a [b]-[β] contrast in both prosodic positions, as illustrated in tableau (17). Such a ranking corresponds to languages that have a continuancy contrast within the phonological class of voiced obstruents, unlike in Spanish. The BOUNDARY-DISRUPTION schema in (21) projects multiple individual constraints, but each one still acts as both a leniter *and* a fortifier, depending on the target consonant's prosodic position. Even though both roles are encoded separately in (21)a,b, it is not possible to split BD(3,0,φ) or any other such constraint into separate lenition and fortition versions. Therefore, the positional neutralization problem in (18) does not arise.

In Spanish, high ranking IDENT(voice) prevents continuity lenition from taking intervocalic voiceless stops all the way to voiced continuants, even though a voiced continuant in the output would create a flatter, more harmonic intensity contour (Katz, 2016: 60). Tableau (28) gives the evaluations of output candidates for the inputs /apa/ and /aba/. Among the candidates for /apa/, BD(3,0,φ) wants 747 to win in (28)c, but this mapping entails a fatal violation of IDENT(voice). Since (28)a,b are tied in their violations of BD(3,0,φ), the decision for optimality is passed down to IDENT(continuant), which selects the fully faithful (28)a. Among the candidates for /aba/, spirantization is allowed because [β] (28)f is faithful to the input voicing specification of /b/, thereby satisfying IDENT(voice).

(28)

	IDENT (voice)	BD (3,0,φ)	IDENT (continuant)	BD (4,0,φ)
☞ a. /apa/ → (apa)φ 717		*		*
b. (aɸa)φ 727		*	*!	*
c. (aβa)φ 747	*!		*	*
d. /aba/ → (aɸa)φ 727	*!	*	*	*
e. (aba)φ 737		*!		*
☞ f. (aβa)φ 747			*	*

The ranking of IDENT(voice) » BD(3,0,φ) » IDENT(continuant) is sufficient to account for Spanish continuity lenition in intervocalic positions. The interaction between BD(3,0,φ) and IDENT(continuant) sets the intensity threshold at the level of voiced stops within the phonological phrase domain. The interaction between IDENT(voice) and BD(3,0,φ) rules out alternations in voicing, effectively limiting the type of continuity lenition to spirantization of obstruents that are already voiced. Additional constraints are required to explain blocking effects after nasals and laterals, as well as the different realization of phrase-final vs. phrase-initial voiced stops, as reflected in Katz's description of the Venezuelan Spanish data. We do not discuss these additional contexts or constraints here, as our focus is on intervocalic contexts in different prosodic domains (see Katz, 2016: 62-64.

4.5 Relative consonantal intensity in Spanish: further empirical support

Although hypothetical, Katz's disruption indices in Table 4.2 are phonetically motivated, and the constraints that refer to them make possible an elegant account of the voiced stop ~ continuant alternation in Venezuelan Spanish. His ranking presents the same relative ordering of consonants as Parker's (2002) intensity ranking for Colombian Spanish in Table 4.1, although Parker includes a few specific segments and rankings that Katz does not. An important question is whether there is any broader empirical support for the intensity indices in Table 4.2 beyond Colombian and Venezuelan varieties of Spanish. In particular, is there further support for the relative intensity relationship among the three dependent variable categories, i.e. PA > TA > Stop, assumed in the present study and other recent works on heritage Spanish? How should Katz's scale accommodate the more nuanced distinction among pure and tense approximants?

Additional evidence in support of the scale comes from previous studies that provide measurements of relative consonantal intensity in four other varieties of contemporary Spanish, as well as in Galician, a related Ibero-Romance language spoken in northwestern Spain that has similar spirantization patterns. In a foundational acoustic study of obstruent consonants in Northern-Central Peninsular Spanish, Martínez Celdrán (1984) reports absolute reference values for both intensity and duration. Table 2.1 lists mean values for five manner classes, arranged from top to bottom as follows: pure approximants, tense approximants, voiced stops, voiceless fricatives, and voiceless stops. In fact, his distinction between two types of approximant is the source of the difference between TA and PA categories assumed in recent studies of U.S. heritage Spanish by Rao (2014, 2015) and Blair and Lease (2021), as well as the experiment reported in Chapters 2 and 3 of this dissertation. The pure approximants [β̞, ð̞, ʝ̞, ɣ̞] are the most intense at 19.81 dB. Curiously, the mean intensity of tense approximants [b̞, d̞, ɟ̞͡ʝ̞, g̞] (12.32 dB) is actually lower than that of voiced noncontinuants [b, d, ɟ͡ʝ̞, g] (15.79 dB), which goes against the idea that greater intensity indicates a more open articulation. Although these absolute values are based on acoustic analysis of carefully selected stimuli words pronounced in a frame sentence by 20 male speakers, it is unclear what methodology Martínez Celdrán (1984) used in measuring the intensity of target obstruents. For example, if the measure were an average of values across the entire span of the obstruent, then the inclusion of the release burst may have raised the overall intensity of voiced stops, more so than a single intensity measurement taken at the obstruent's minimum dB value. Furthermore, the lack of inferential statistics makes it difficult to know whether the relative intensity differences between adjacent manner classes reported in Table 2.1 are significant. On the other hand, the duration means generally support Katz's values, as (i) voiceless fricatives and stops are relatively closer in duration to each other, (ii) both voiceless obstruents are longer than the voiced obstruents, and (iii) the duration mean for voiced obstruents decreases as their articulation becomes more open.

Table 4.4 Mean values of intensity and duration, with standard deviations, for consonant manner classes in Northern-Central Peninsular Spanish

consonant manner classes	mean intensity in dB (stdev)	mean duration in ms (stdev)
β̞, ð̞, ʝ̞, ɣ̞	19.81 (3.66)	50.53 (9.36)
b̞, d̞, ɟ̞͡ʝ̞, g̞	12.32 (4.55)	55.65 (13.91)
b, d, ɟ͡ʝ̞, g	15.79 (5.3)	57.18 (12.86)
f, θ, s, x	7.43 (4.63)	98.36 (32.87)
p, t, k	2.5 (2.23)	87.66 (16.39)

(based on Martínez-Celdrán, 1984: 96; see also 2004: 205-208)

Lavoie (2001) presents intensity ratio measurements of experimental data collected from four male speakers of northern Mexican Spanish, who pronounced carefully constructed lists of words embedded in a frame sentence. The same method was used to gather comparable data from five native speakers of American English. Table 4.5 shows a relative ordering of mean intensity values for noncontinuant and continuant consonants, based on a pooling together of all Mexican Spanish participant data. The intensity measurements were calculated by subtracting the average RMS amplitude in dB of the target consonant from that of a reference vowel, the /i/ of *Diga* in the frame sentence *Diga* _____ *para mí* 'Say _____ for me'. Negative values denote consonants of greater intensity relative to the vowel, and positive values, lesser intensity. Lavoie assumes that in Spanish, voiced obstruents in the underlying representation are actually continuants, more specifically, approximants, which strengthen to stops in contexts of fortition. The IPA down tack diacritic is included beneath each symbol [β̞, ð̞, ɣ̞] in the [+continuant] column to make it clear that they are approximants and not voiced fricatives. The intensity means are based exclusively on intervocalic position, where the approximants are the expected realization, and voiced stops in fortition contexts presumably would be relatively less intense. It is noteworthy that dorsal [ɣ̞] patterns as the least intense of the three approximants in Lavoie's Mexican Spanish data. This asymmetry is replicated by the findings of the present study on Colombian heritage Spanish and of recent studies on other Spanish varieties, in which the dorsal tends to be more constricted than non-dorsals (see Chapter 3). Unlike Martínez-Celdrán (1984), Lavoie does not classify approximants by their degree of openness, choosing instead to collapse them all into the same category. Whereas Parker (2002) found only noncontinuant realizations of the voiced palatal affricate [ɟ͡ʝ] in Colombian Spanish, Lavoie found affrication of the voiced palatal glide [j] to be quite rare in Mexican Spanish. Despite some different segment rankings and the lack of distinction between pure and tense approximants, Lavoie's intensity scale generally supports those of Martínez Celdrán (1984) and Parker (2002), at least for the major consonant classes.

Table 4.5 Mean intensity values for Mexican Spanish consonants

[–continuant]	[+continuant]	mean intensity in dB
n, ɲ	j	–1
m	l	0
	ð̞	2
	β̞, r	3
	ɣ̞, ɾ	4
	v	5
		…
	x	12
p, ʧ	s	13
t		14
		…
	f	16
k		17

(based on Lavoie, 2001: Chapter 4, Tables 4.1 and 4.2)

Martínez-Celdrán and Regueira (2008) present an acoustic analysis of voiced stops in Galician. Their methodology involved different measurements of intensity and duration for voiced stops after a vowel, /s/, and a liquid, based on conversational speech recordings of three female bilingual speakers. They adopt an earlier proposal by Martínez-Celdrán (2004), who "postulates APPROXIMANT as a super-category that includes lateral and rhotic sounds, semivowels, and a set of obstruent consonants such as [β̞, ð̞, ʝ̞, ɣ̞] that have no specific name, and for which the author proposes the label SPIRANT, following Martinet (1956)" (Martínez-Celdrán & Regueira, 2008: 52). The researchers use the terms *open* and *closed* to distinguish between two types of spirant approximant. “Closed spirants are more like stops, but without a release burst. Open spirants are featured by their shorter duration and higher intensity” (66). However, we continue to use the terms *pure* and *tense*, respectively, in keeping with Rao (2014, 2015) and the methodology outlined in Chapter 2. Table 4.6 lists four allophone categories, along with overall frequency and means for intensity and duration, in order from top to bottom: pure approximants, tense approximants, voiced fricatives, and voiced stops. Only seven tokens were categorized as a *vocalic approximant,* which is even less constricted than the pure approximant. Vocalic allophones are grouped together with the pure approximants in the values presented here. Similarly, voiced fricatives are the least frequent of the four categories at only fourteen tokens—just 4.67% of the total 300 tokens in the data set. Pure approximants are the most frequent allophone overall at 66%. Separating out the allophone counts for intervocalic position alone, the researchers show that approximants are overwhelmingly favored between vowels: 88.6% approximants (pure and tense combined) > 10.2% stops > 1.2% fricatives (Martínez-Celdrán & Regueira, 2008: 62). Fricative allophones are limited primarily to the context of a preceding /s/ and are quite rare in general, constituting only 4.67% of the entire data set, as seen in Table 4.6. Inferential statistics (ANOVAs and Scheffé’s post-hoc tests) reveal that the differences between adjacent manner classes are significant, although some caution is warranted in interpreting “the intermediate position of fricatives regarding intensity” (64). The smallest difference in intensity means is between tense approximants and voiced fricatives, but the low token count of the latter prevents drawing firm conclusions.

Table 4.6 Mean intensity values for allophones of voiced stops /b, d, ɡ/ in Galician

segment	number of tokens (n=300)		mean intensity in dB (stdev)		mean duration in dB (stdev)	
β̞, ð̞, ɣ̞	198	(66%)	–20.62	(6.53)	40.88	(10.62)
b̞, d̞, ɡ̞	40	(13.33%)	–26.40	(6.76)	49.68	(15.16)
β, ð, ɣ	14	(4.67%)	–24.64	(7.14)	39.50	(12.44)
b, d, ɡ	48	(16%)	–30.98	(7.86)	49.12	(13.37)

(based on Martínez-Celdrán & Regueira, 2008: 61–63)

In an acoustic study of Chilean Spanish, a more innovative lenition variety compared to other dialects, Figueroa (2016) used the same elicitation technique of embedding controlled word stimuli in carrier phrases, with ten native speakers from Santiago, Chile. The study focuses exclusively on the approximant realizations of intervocalic /b, d, ɡ/. Figueroa calculated normalized intensity ratios by dividing the minimum dB of the target consonant by the maximum dB of the following segment. Ratio values closer to one indicate greater intensity. Table 4.7 includes the additional category from Martínez-Celdrán and Regueira's (2008) study of Galician, vocalic approximant, which is necessary to reflect the greater tendency toward intervocalic deletion in Chilean Spanish. We transcribe the vocalic approximants here using relatively smaller versions of the pure approximant symbols [β̞, ð̞, ɣ̞] placed between parentheses, which are intended to denote their perceptual closeness to deletion: [(β, ð, ɣ)]. A relative ordering emerges, vocalic > pure > tense approximants, based on statistically significant differences between the adjacent categories as verified by multinomial logistic regression analyses. This confirms the hypothesized correlation between increases in intensity and articulatory openness, at least for the class of approximant allophones.

Table 4.7 Normalized intensity ratios for approximant allophones of /b, d, g/ in Chilean Spanish.

segment	intensity ratio
	1.0
(β̞, ð̞, ɣ̞)	.95
	.90
β̞, ð̞, ɣ̞	.85
	.80
b̞, d̞, g̞	.75
	.70

(based on Figueroa, 2016: 85)

Finally, Broś et al. (2021) analyze continuity lenition effects in the Spanish of Gran Canaria. The most innovative of the varieties examined here, Canary Island Spanish is well known for the voicing of intervocalic /p, t, k, ʧ/, as well as its relatively more advanced stages of spirantization and deletion of intervocalic voiced stops. Based on conversational interview data from 44 native speakers (18 females, 26 males), the researchers combine several continuous measurements, some tried and tested and one novel, the harmonics-to-noise ratio, which indicates the degree of periodicity in the segment. They report that 70% of all underlying noncontinuants are lenited, most often to an approximant. Intensity measures are also found to differ significantly as a function of stress and position in the word, whereby the target consonants show greater degrees of intensity in unstressed and word-medial intervocalic contexts. Although all weakened realizations are possible for both voiceless and voiced stops, the underlying contrasts between /p, t, k/ and /b, d, g/ are largely maintained in the gradient phonetic details of speech production.

> "Since all the phonetic parameters show the same dependencies, we can confirm that we are dealing with postvocalic weakening leading to greater continuity of the speech stream (shorter, more vowel-like segments with a higher degree of harmonicity), in line with Katz's (2016) predictions [...] At the same time, the deletion rate shows us the final outcome of this ongoing change: /p, t, k, b, d, g/ tend to be realized with a greater aperture, to the extent that they vocalize or elide. This is best illustrated by the changes in the intensity contour, which becomes flatter the shorter and more sonorous a given sound becomes" (Broś et al., 2021: 27-28).

Contrast maintenance and sensitivity to prosodic structure are both hallmarks of continuity lenition, which Broś et al. argue to be the driving force behind the weakening of both voiceless and voiced stops in Gran Canaria Spanish.

The authors propose a gradient phonetic scale including six degrees of aperture along which underlying contrasts are maintained at the surface. Table 4.8 lists the relevant allophones by intensity difference values, which were calculated by subtracting the minimum dB of the target consonant from the maximum dB of the preceding segment. Smaller values denote greater articulatory openness. Segment classes are arranged from top to bottom as follows: (i) very open voiced approximants (derived from /b, d, g/ after an underlying vowel); (ii) moderately open voiced approximants (< /p, t, k/ in any position and < /b, d, g/ after a deleted coda /s/, e.g. *las velas* [la.ˈβe.la] 'the candles'); (iii) less constricted voiced stops (< /p, t, k, b, d, g/ after an underlying vowel); (iv) moderately constricted, unlenited voiced stops (after a deleted coda /s/);

(v) less constricted voiceless stops (after an underlying vowel); and (vi) fully constricted, unlenited voiceless stops (after a deleted coda /s/). Broś et al. (2021: 26) argue that "there are indeed two types of [p t k], two types of [b d g] and two types of [β̞, ð̞, ɣ̞], which are differentially used depending on the process of phonological deletion, meaning that the observed differences are not purely phonetic. Rather, they seem to be categorical." In comparison with the previously reviewed studies, the scale in Table 4.8 is by far the most detailed intensity-based ranking of Spanish stop allophones. It is probably no coincidence that a scale this fine-grained should emerge most clearly in a variety with such advanced stages of stop lenition.

Table 4.8 Intensity difference values (approximate) for allophones of /p, t, k, b, d, g/ in Gran Canaria Spanish

segments	intensity difference in dB
	0
	3
β̞, ð̞, ɣ̞	6
β, ð, ɣ	9
	12
b̞, d̞, g̞	15
b, d, g	18
p̞, t̞, k̞	21
p, t, k	24
	27
	30

(based on Broś et al., 2021: 31)

Table 4.9 is a summary of six different intensity rankings, presented in chronological order by source. The table includes all of the consonants examined in each study, with those of greater intensity ordered above those of lesser intensity. Shaded cells and boldface indicate the regions of each hierarchy that are occupied by the allophones of /b, d, ɡ/ and, if present, /ɟ͡ʝ/. To be sure, there are some discrepancies across the hierarchies. One is the curious reversal of tense approximants [b̞, d̞, ɟ͡ʝ̞, ɡ̞] below voiced noncontinuants [b, d, ɟ͡ʝ, ɡ] in Martínez-Celdrán's (1984) ranking for Northern-Central Peninsular Spanish. Another is that Lavoie's (2001) hierarchy for Mexican Spanish is the only one to impose a total ordering of the four continuant allophones j > ð̞ > β̞ > ɣ̞.

Table 4.9 Hierarchies of relative consonantal intensity across six Ibero-Romance varieties

Martínez-Celdrán (1984)	Lavoie (2001)	Parker (2002)	Martínez-Celdrán and Regueira (2008)	Figueroa (2016)	Broś et al. (2021)
β̞, ð̞, j̞, ɣ̞	n, ɲ, **j**	w	**β̞, ð̞, ɣ̞**	(β̞, ð̞, ɣ̞)	**β̞, ð̞, ɣ̞**
b, d, ɟ͡ʝ̞, g	m, l	l	**b̞, d̞, g̞**	**β̞, ð̞, ɣ̞**	**β, ð, ɣ**
b̞, d̞, ɟ̞͡ʝ̞, g̞	**ð̞**	ɾ	**β, ð, ɣ**	**b̞, d̞, g̞**	**b̞, d̞, g̞**
f, θ, s, x	**β̞**, r	r	**b, d, g**		**b, d, g**
p, t, k	**ɣ̞**, ɾ	m, n, ɲ			p̞, t̞, k̞
	v	**β̞, ð̞, ɣ̞**			p, t, k
	x	**b, d, g**			
	p, ʧ, s	**ɟ͡ʝ**			
	t	h			
	f	f, s			
	k	p, t, k, ʧ			

In contrast to Lavoie's study, Parker (2002) finds only an affricate realization of palatal [ɟ͡ʝ̞], which in Colombian Spanish ranks just below the voiced stops. While Martínez-Celdrán and Regueira (2008: 56) transcribe the occasional voiced fricative allophones in Galician as [β, ð, ɣ], these true fricatives are vanishingly rare enough that the other hierarchies do not even include them. Figueroa's (2016) ranking teases apart Martínez-Celdrán and Regueira's vocalic approximants, transcribed here as [$^{(\text{β̞, ð̞, ɣ̞})}$], from the pure and tense ones, while Broś et al. (2021) increase the total number of subdivisions even further:

> "For instance, Martínez-Celdrán and Regueira (2008) propose three types of approximants in Spanish: closed, open [i.e. tense, pure—CJL] and vocalic. Their closed approximants, however, would at least partially overlap with our voiced stops, as their main criterion is a stop-like pronunciation without a burst, while the presence of formant structure is a property of the open series" (34).

Another difference is that Martínez-Celdrán and Regueira (2008) transcribe true voiced fricatives as [β, ð, ɣ], which are the same phonetic symbols that Broś et al. (2021) use to represent moderately open voiced approximants. We follow Martínez-Celdrán and Regueira's usage, in which [β, ð, ɣ] denote voiced fricative allophones with some degree of aperiodic noise in the mid to upper frequency range. True fricative allophones of intervocalic voiced stops were unattested in our Colombian heritage data, further confirming that Spanish spirantization is really approximantization, not fricativization.

Despite the minor differences across studies, the summary provides broader empirical support for the intensity indices proposed by Katz (2016). The overall generalization is that an increase in intensity correlates with an increase in articulatory openness. This methodological assumption underlies all of the relevant acoustic studies mentioned in Chapter 2 (Amengual, 2019; Blair & Lease, 2021; Cabrelli Amaro, 2017; Carrasco et el., 2012; Carrasco, 2008; Colantoni & Marinescu, 2010; Cole et al., 1999; Eddington, 2011; Hualde et al., 2010, 2011; Ortega-Llebaria, 2004; Rao, 2014, 2015). The relationship is best observed in the most innovative lenition varieties: vocalic approximants are more intense than pure approximants, which are more intense than tense approximants, which are more intense than voiced stops. Although his formal analysis of spirantization in Venezuelan Spanish does not include the fine-grained distinction between pure and tense approximants, Katz (2016: 67) later proposes to assign an intensity index of 5 to "voiced approximants," thereby ranking them at the same level as the higher-intensity rhotic tap [ɾ].

Table 4.10 shows how Rao's (2014, 2015) three dependent variable categories align with Katz's intensity indices, which were first presented as part of Table 4.2. If we assume that by "voiced approximants" Katz means specifically the pure approximants, then another plausible assumption would be that the tense approximants pattern the same as "voiced continuants" at level 4, ranked just above the voiced stops at level 3. These minimal assumptions capture the asymmetrical intensity relationships among Rao's categories, i.e. PA > TA > Stop. Presumably, the rarely attested, true voiced fricatives transcribed as [β, ð, ɣ] by Martínez-Celdrán and Regueira (2008) would rank at level 3 as well. Level 6 could plausibly accommodate the most open vocalic approximants [$^{(\text{β̞, ð̞, ɣ̞})}$], which are the closest to glides in terms of both intensity and the presence of formant structure, but this issue does not bear directly on the present discussion.

Table 4.10 Alignment of Rao's (2014, 2015) dependent variable categories PA, TA, and voiced Stop to Katz's (2016) scale of relative consonantal intensity

relative consonantal intensity (Katz 2016)			dependent variable categories (Rao 2015)	
J	glide	6		
R	tap	5	PA	β̞, ð̞, ɣ̞
Z	voiced continuant	4	TA	b̞, d̞, g̞
D	voiced stop	3	Stop	b, d, g
S	voiceless continuant	2		
T	voiceless stop	1		

What matters is not the actual distance between adjacent segments, which can vary by language and dialect, but rather the relative ordering of major consonant classes within the overall intensity hierarchy. Lavoie makes the same observation in comparing intensity measurements from Mexican Spanish and American English participants:

> "Except for the nasals, each language has different intensity ratios for each manner of articulation, reinforcing the notion that intensity is a measure with relative value. While the actual values differ, the relative positions on the intensity hierarchy for the manners of articulation are about the same" (Lavoie, 2001: Section 4.1).

Most importantly, the mappings in Table 4.10 suggest that Katz's theory of boundary disruption provides an analytical framework that can account for the distribution of PA, TA, and Stop allophones of /b, d, g/ in Colombian Heritage Spanish.

In the remainder of this chapter, we develop an OT analysis of intervocalic spirantization as prosodically driven continuity lenition that incorporates the distinction between pure and tense approximants and successfully models the effects of phoneme, stress, and task found reported in Chapter 3.

4.6 Accounting for continuity lenition effects in U.S. Spanish of Colombian heritage

Katz's disruption indices in Table 4.2 incorporate values for both intensity and duration. However, although weakening is generally associated with shorter articulations, the main acoustic correlate of spirantization is not duration but intensity.[10] This is the reason why the duration parameter is set to 0 in the BOUNDARY-DISRUPTION constraints projected in (22). In any event, the methodology of Chapter 2 does not include duration as a dependent variable. For boundary disruption phenomena that are driven primarily by intensity, we propose the more restrictive constraint schema in (29), which omits any reference to duration values. INTENSITY constraints follow the same template as our revised definition of BOUNDARY-DISRUPTION in (21). The disjunction between non-edge-adjacent (29)a and edge-adjacent (29)b positions is captured as two separate instructions for assigning a violation mark:

[10] Cohen Priva and Gleason (2020) argue that the primary cause of lenition is a reduction in duration, while changes in intensity arise as a secondary consequence. For Gran Canaria Spanish, Broś et al. (2021: 22) report that, although word-medial stops do show greater intensity (and lenition) than word-initial stops, they are also unexpectedly longer than word-initial ones. "In our data, we have changes in intensity *despite* the lack of triggering changes in duration, which raises doubts about an analysis in which duration has precedence over other features" (28).

(29) INTENSITY≤n_{DOMAIN}

Assign a violation for

a. every consonant of intensity ≤n that is not edge-adjacent in a prosodic DOMAIN

b. every edge-adjacent consonant in a prosodic DOMAIN that is not of intensity ≤n.

This schema combines intensity levels and prosodic domains to project specific INTENSITY constraints, six of which are shown in (30). These constraints may be read aloud as “intensity, three or lower, phonological phrase,” “intensity, four or lower, max word,” and so on:

(30)	INTENSITY≤3φ	INTENSITY≤3ω_{max}	INTENSITY≤3ω_{min}
	INTENSITY≤4φ	INTENSITY≤4ω_{max}	INTENSITY≤4ω_{min}

As explained in Section 4.4, BOUNDARY-DISRUPTION constraints form stringency hierarchies that impose intensity thresholds on segments appearing in edge-adjacent and non-edge-adjacent positions at different levels of the prosodic hierarchy (see quasi-tableaux (23) through (26)). Each BOUNDARY-DISRUPTION constraint functions as a single, unitary markedness constraint with respect to the faithfulness constraint IDENT(continuant), as is required in order to explain why continuity lenition never involves positional neutralization of phonological continuancy contrasts. In the same way, our INTENSITY constraints in (30) are also stringent in relation to each other and unitary in relation to faithfulness.

We also propose two, more conventional markedness constraints that penalize pure and tense approximants, respectively:

(31) a. *PA Assign a violation for every pure approximant [β̞, ð̞, ɣ̞].

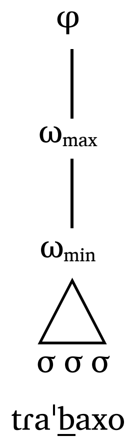
b. *TA Assign a violation for every tense approximant [b̞, d̞, g̞].

Since pure and tense approximants are both [+continuant] segments, faithfulness to this feature is not violated by input-output mappings such as /β̞/ → [b̞] and /b̞/ → [β̞], only by mappings between [–continuant] /b/ and [+continuant] [b̞] or [β̞], and *vice versa.* The prediction is that no language has a phonological contrast based solely on the gradient difference in aperture between pure and tense approximants, as UG contains no faithfulness constraint that directly regulates this subphonemic distinction (Kirchner, 1997).

The interaction among IDENT(continuant), *PA, *TA, and INTENSITY constraints captures the implicational relationships among prosodic domain boundaries at which voiced stops and approximants alternate. Since Spanish voiced obstruents do not contrast phonologically for continuancy, we assume that IDENT(continuant) is ranked sufficiently low in the grammar that the relevant INTENSITY constraints always prevent potential input contrasts between, e.g. /b/ and either /b̞/ or /β̞/, from mapping faithfully to the output. Therefore, we generally omit IDENT(continuant) from the tableaux and focus instead on the interactions among markedness constraints. Inputs need not be considered, although doing so would merely confirm that our analysis respects ROTB. Potential input contrasts would be neutralized in the output by high ranking markedness constraints, as first illustrated with the cover constraint LENITIONFORTITION in tableau (16).

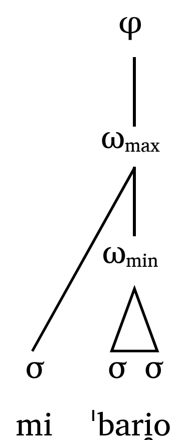
Figure 4.4 Prosodic representations (exhaustive) of *trabajo* 'job' (a), *mi barrio* 'my neighborhood' (b), and *curso básico* 'basic course' (c)

(a)



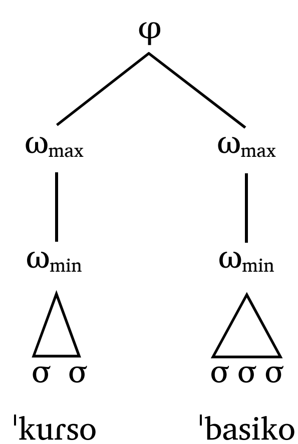
(((tɾaˈ.b̲a.xo)ω_{min})ω_{max})φ

(b)



(((mi (ˈ.b̲a.ri̯o)ω_{min})ω_{max})φ

(c)



((('kuɾ.so)ω_{min})ω_{max}((ˈ.b̲a.si.ko)ω_{min})ω_{max})φ

We illustrate the analysis using the same set of representative examples, one for each of the three levels of our independent variable prosodic domain. Figure 4.4 gives the examples in both arboreal and bracketed prosodic representations. The arrows indicate the highest domain in the tree in which /b/ is the initial segment: the syllable in word-medial position (a), the minimal prosodic word (b), and the maximal prosodic word (c). For the sake of completeness, both the minimal and maximal projections of the prosodic word are explicitly shown in (a) and (c), even though no unstressed function word is adjoined to the relevant prosodic word in these two examples. Since the experimental design in Chapter 2 did not include prosodic boundaries higher than the maximal prosodic word, the analysis will consider only the three domain-initial contexts in Figure 4.4, all of which are medial within the phonological phrase.

4.7 A typology of continuity lenition effects: the basic model

As noted in the discussion surrounding Table 4.3 in Section 4.4, an advantage of constraints in a stringency hierarchy is that their universal ranking need not be stipulated in order to explain typological implications, which are already reflected in the superset-subset relationships that exist among violation marks. Still left open is the question of how INTENSITY constraints interact with each other and other markedness constraints in actual grammars.

The factorial typology (Prince & Smolensky, 2004: 33, Chapter 6; McCarthy, 2002: 12, 2008: 235-259) of a constraint set refers to the total number of constraint rankings that predict different surface distributions. The downside of stringency when working with more than just a handful of constraints is that computing factorial typologies by hand becomes too laborious and more susceptible to human error. Therefore, we used OTSoft (Hayes et al., 2003) to search the typological space of predicted rankings based on a model that includes the six INTENSITY constraints in (30) and the two segmental markedness constraints *PA and *TA in (31). Given its low ranking in Spanish, IDENT(continuant) was not included in the model. Out of 40,320 logically possible rankings of eight total constraints, there emerged just ten distinct, maximally simple grammars each consisting of two ranking strata. Table 4.11 shows the two dominant constraints that are ranked on the highest stratum within each of the ten grammars G1–G10, along with the predicted distributions of our dependent variable categories. Boldface and two degrees of shading denote allophones of relatively greater intensity.

Table 4.11 Factorial typology of prosodically driven continuity lenition across three prosodic domains

		(((V._V)ω_{min})ω_{max})φ	((V(._V)ω_{min})ω_{max})φ	(((V))ω_{max}((._V))ω_{max})φ
G1	*PA, *TA	Stop	Stop	Stop
G2	INT≤3ω_{min}, *PA	**TA**	Stop	Stop
G3	INT≤3ω_{min}, INT≤4ω_{min}	**PA**	Stop	Stop
G4	INT≤3ω_{max}, *PA	**TA**	**TA**	Stop
G5	INT≤3ω_{max}, INT≤4ω_{min}	**PA**	**TA**	Stop
G6	INT≤3ω_{max}, INT≤4ω_{max}	**PA**	**PA**	Stop
G7	INT≤3φ, *PA	**TA**	**TA**	**TA**
G8	INT≤3φ, INT≤4ω_{min}	**PA**	**TA**	**TA**
G9	INT≤3φ, INT≤4ω_{max}	**PA**	**PA**	**TA**
G10	INT≤3φ, INT≤4φ	**PA**	**PA**	**PA**

The dark shaded PA cells occupy the lower left quadrant of the typological space, and the unshaded voiced Stop cells, the upper right quadrant. The ten distributions range from Stops in all three contexts, as predicted by G1, to PAs in all three contexts, as predicted by G10. Horizontal broken lines divide the grammars into four blocks, which can be said to differ in overall relative "strength" depending on the ratio of cells occupied by PAs vs. TAs and Stops. In between the two endpoints of the typology, the permutation of allophones shows the by now familiar superset-subset relationships. A PA in a given dark shaded cell entails PAs in all dark cells to the left in the same row. Conversely, a Stop in a given unshaded cell entails Stops in all unshaded cells to the right in the same row. Although they show the same rightward directionality of entailment as Stops, TAs occupy the space in between the other two categories. The light shaded TA cells are potentially bounded by PAs on the left and by Stops on the right. For example, G9 predicts TAs at only the maximal prosodic word boundary, G8 at minimal and maximal prosodic word boundaries, and G7 in all three prosodic contexts, including the syllable boundary within the minimal prosodic word. In turn, G4 and G5 predict TAs in a subset of the contexts predicted by G7–G9, and only Stops appear at the maximal prosodic word boundary. Finally, G2 predicts TAs at only the syllable level in medial position of the minimal prosodic word vs. Stops at both the minimal and maximal prosodic word boundaries.

The diagonal, stepwise patterns visible in Table 4.11 reflect the implicational thresholds established by INTENSITY constraints at different prosodic boundary levels. Implicit in any formal statement of possible grammars is also a statement about what distributions are predicted to be impossible, or at least improbable, in human languages. The prediction of our factorial typology is that there should be no language in which the implicational relationships among prosodic positions run in the opposite directions, i.e. rightward for PAs vs. leftward for TAs and Stops. In one example of an impossible pattern, the relative positions of PA and Stop cells in a given row would be reversed, i.e. Stops would systematically appear instead of PAs at the word-medial syllable boundary, and PAs instead of Stops at the maximal prosodic word-boundary, e.g. *trabajo* [tɾaˈ.ba.xo] 'job' vs. *curso básico* [ˈkuɾ.so ˈβ̞a.si.ko] 'basic course'. This impossible distribution goes against the predictions of G3, G5, and G6. In another example, TAs would systematically appear instead of PAs at the word-medial syllable boundary, and PAs instead of TAs at the higher prosodic boundaries, e.g. *trabajo* [tɾaˈ.b̥a.xo] vs. *mi barrio* [mi ˈβ̞a.ri̯o] and/or *curso básico* [ˈkuɾ.so ˈβ̞a.si.ko]. This impossible distribution runs counter to G5, G8, and G9. A third impossible distribution would have TAs appearing to the exclusion of Stops at the maximal prosodic word boundary, and Stops to the exclusion of TAs at the minimal prosodic word boundary, e.g. *mi barrio* [mi ˈba.ri̯o] vs. *curso básico* [ˈkuɾ.so ˈb̥a.si.ko], thereby contradicting G4 and G5.

To illustrate the typology of predicted distributions, we present a separate tableau for each grammar, starting with G10 in the "weakest" block of grammars, where continuity lenition is the most extensive, and working our way up to G1, the sole member of the "strongest" block where continuity lenition is completely absent. Each tableau combines three separate evaluations, one for each level of our independent variable, prosodic domain. The output candidates are the three bracketed representations in Figure 4.4. Each candidate presents a different allophone in the target intervocalic position, i.e. PA [β̞], TA [b̥], or Stop [b], which in turn shapes the intensity contour of the [VCV] sequence.

Tableau (32) illustrates G10, in which the two INTENSITY constraints relativized to the phonological phrase are crucially ranked above all other constraints. For reasons of space, *PA and *TA are the only dominated constraints shown on the lower ranking stratum in the tableau, to the right of the solid vertical line that indicates the crucial ranking. Because the Stop [b] of intensity level 3 is not adjacent to a phonological phrase edge, (32)c,f,j each incur violations of both INTENSITY≤3φ, which, under stringency, entail violations of INTENSITY≤4φ. As these two constraints are not crucially ranked with respect to one other, and there is another competing candidate that violates neither constraint, either violation counts as fatal, which we indicate by enclosing the exclamation points in parentheses. Candidates (32)b,e,i fatally violate INTENSITY≤4φ because the TA [b̞] of intensity level 4 is not adjacent to a phonological phrase edge. The optimal candidates (32)a,d,h satisfy both INTENSITY constraints while violating lower ranked *PA.

(32)

G10	INT≤3 φ	INT≤4 φ	*PA	*TA
☞ a. $(((\text{tɾa.β̞a.xo})\omega_{min})\omega_{max})\varphi$ 7 57			*	
b. $(((\text{tɾa.b̞a.xo})\omega_{min})\omega_{max})\varphi$ 7 47		*!		*
c. $(((\text{tɾa.ba.xo})\omega_{min})\omega_{max})\varphi$ 7 37	*(!)	*(!)		
☞ d. $(((\text{mi(.β̞ari̯o})\omega_{min})\omega_{max})\varphi$ 7 57			*	
e. $(((\text{mi(.b̞a.ri̯o})\omega_{min})\omega_{max})\varphi$ 7 47		*!		*
f. $(((\text{mi(.ba.ri̯o})\omega_{min})\omega_{max})\varphi$ 7 37	*(!)	*(!)		
☞ h. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.β̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 57			*	
i. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.b̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 47		*!		*
j. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.ba.si.ko})\omega_{min})\omega_{max})\varphi$ 7 37	*(!)	*(!)		

The only difference between G10 and G9, illustrated in tableau (33), is that previously low ranked INTENSITY≤4ω_{max} has switched rankings with INTENSITY≤4φ, which now occupies the lower constraint stratum but is not shown here. As a result, the optimal realization at the maximal prosodic word boundary is now TA [b̥] instead of PA [β̞]. Whereas INTENSITY≤4φ prefers the flatter 757 contour at the maximal prosodic word boundary in (32)h, INTENSITY≤4ω_{max} instead requires 747 in (33)i. PAs remain optimal at the lower prosodic boundaries within the maximal prosodic word in (33)a,d, as in G10.

(33)

G9	INT≤3 φ	INT≤4 ω_{max}	*PA	*TA
☞ a. (((tɾa.β̞a.xo)ωmin)ωmax)φ 7 57			*	
b. (((tɾa.b̥a.xo)ωmin)ωmax)φ 7 47		*!		*
c. (((tɾa.ba.xo)ωmin)ωmax)φ 7 37	*(!)	*(!)		
☞ d. (((mi(.β̞a.ɾi̯o)ωmin)ωmax)φ 7 57			*	
e. (((mi(.b̥a.ɾi̯o)ωmin)ωmax)φ 7 47		*!		*
f. (((mi(.ba.ɾi̯o)ωmin)ωmax)φ 7 37	*(!)	*(!)		
h. (((kuɾ.so)ωmin)ωmax((.β̞a.si.ko)ωmin)ωmax)φ 7 57		*!	*	
☞ i. (((kuɾ.so)ωmin)ωmax((.b̥a.si.ko)ωmin)ωmax)φ 7 47				*
j. (((kuɾ.so)ωmin)ωmax((.ba.si.ko)ωmin)ωmax)φ 7 37	*!			

Moving from G9 to G8 in tableau (34), we see that INTENSITY≤4ω_{min} has switched rankings with INTENSITY≤4ω_{max}. As a result, the preference for TA [b̥] is now extended to encompass both the minimal (34)e and maximal (34)i prosodic word boundary contexts, while PAs still remain optimal within the minimal prosodic word in (34)a, as in G9 and G10.

(34)

G8	INT≤3 φ	INT≤4 ω_{min}	*PA	*TA
☞ a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57			*	
b. (((tɾa.b̞a.xo)ω_{min})ω_{max})φ 7 47		*!		*
c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*(!)	*(!)		
d. (((mi(.β̞a.ɾi̯o)ω_{min})ω_{max})φ 7 57		*!	*	
☞ e. (((mi(.b̞a.ɾi̯o)ω_{min})ω_{max})φ 7 47				*
f. (((mi(.ba.ɾi̯o)ω_{min})ω_{max})φ 7 37	*!			
h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57		*!	*	
☞ i. (((kuɾ.so)ω_{min})ω_{max}((.b̞a.si.ko)ω_{min})ω_{max})φ 7 47				*
j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37	*!			

The preference for TA [b̞] is extended to all three prosodic contexts in G7, as shown in (35)b,e,i. Fatal violations of INTENSITY≤3φ rule out the candidates that have Stop [b] at each prosodic level (35)c,f,j. This time, the other high ranking constraint is one of the segmental markedness constraints, *PA, which rules out (35)a,d,h.

(35)

G7		INT≤3φ	*PA	*TA
	a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57		*!	
☞	b. (((tɾa.b̞a.xo)ω_{min})ω_{max})φ 7 47			*
	c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*!		
	d. (((mi(.β̞a.ri̯o)ω_{min})ω_{max})φ 7 57		*!	
☞	e. (((mi(.b̞a.ri̯o)ω_{min})ω_{max})φ 7 47			*
	f. (((mi(.ba.ri̯o)ω_{min})ω_{max})φ 7 37	*!		
	h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57		*!	
☞	i. (((kuɾ.so)ω_{min})ω_{max}((.b̞a.si.ko)ω_{min})ω_{max})φ 7 47			*
	j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37	*!		

The cells generated by the block of grammars G10–G7 constitute the weakest region of the typological space defined in Table 4.11, with PAs and TAs occupying symmetrical subregions. In these four grammars, INTENSITY≤3φ prevents voiced Stops from appearing in any of three prosodic boundary contexts because they are all medial within the phonological phrase. The optimal distribution of the two approximant categories depends on which other constraint is high ranking: INTENSITY≤4φ (32)a,d,h, INTENSITY≤4ω_{max} (33)a,d,i, INTENSITY≤4ω_{min} (34)a,e,i, and *PA (35)b,e,i.

The block of grammars G6–G4 demarcates a relatively stronger region of cells in which voiced Stops are obligatory at the highest of the three prosodic boundary contexts, thanks to the shared high ranking of INTENSITY≤3ω_{max}. The following three tableaux illustrate these grammars:

(36)

	G6	INT≤3 ω_{max}	INT≤4 ω_{max}	*PA	*TA
☞	a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57			*	
	b. (((tɾa.ḅa.xo)ω_{min})ω_{max})φ 7 47		*!		*
	c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*(!)	*(!)		
☞	d. (((mi(.β̞a.ɾi̯o)ω_{min})ω_{max})φ 7 57			*	
	e. (((mi(.ḅa.ɾi̯o)ω_{min})ω_{max})φ 7 47		*!		*
	f. (((mi(.ba.ɾi̯o)ω_{min})ω_{max})φ 7 37	*(!)	*(!)		
	h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57	*(!)	*(!)	*	
	i. (((kuɾ.so)ω_{min})ω_{max}((.ḅa.si.ko)ω_{min})ω_{max})φ 7 47	*!			*
☞	j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37				

(37)

G5		INT≤3 ω_{max}	INT≤4 ω_{min}	*PA	*TA
☞	a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57			*	
	b. (((tɾa.ḅa.xo)ω_{min})ω_{max})φ 7 47		*!		*
	c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*(!)	*(!)		
	d. (((mi(.β̞a.ɾi̯o)ω_{min})ω_{max})φ 7 57		*!	*	
☞	e. (((mi(.ḅa.ɾi̯o)ω_{min})ω_{max})φ 7 47				*
	f. (((mi(.ba.ɾi̯o)ω_{min})ω_{max})φ 7 37	*!			
	h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57	*(!)	*(!)	*	
	i. (((kuɾ.so)ω_{min})ω_{max}((.ḅa.si.ko)ω_{min})ω_{max})φ 7 47	*!			*
☞	j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37				

(38) G4	INT≤3 ω_{max}	*PA	*TA
a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57		*!	
☞ b. (((tɾa.b̞a.xo)ω_{min})ω_{max})φ 7 47			*
c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*!		
d. (((mi(.β̞a.ɾi̯o)ω_{min})ω_{max})φ 7 57		*!	
☞ e. (((mi(.b̞a.ɾi̯o)ω_{min})ω_{max})φ 7 47			*
f. (((mi(.ba.ɾi̯o)ω_{min})ω_{max})φ 7 37	*!		
h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57	*(!)	*(!)	
i. (((kuɾ.so)ω_{min})ω_{max}((.b̞a.si.ko)ω_{min})ω_{max})φ 7 47	*!		*
☞ j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37			

INTENSITY≤3ω_{max} rules out (36)h,i, (37)h,i, and (38)h,i because neither PAs nor TAs satisfy the requirement of dropping to intensity level 3 or lower at the maximal prosodic word boundary. The optimal distribution of approximant categories across the lower prosodic boundaries depends on the other high ranking constraint: INTENSITY≤4ω_{max} (36)a,d, INTENSITY≤4ω_{min} (37)a,e , and *PA (38)b,e.

Occupying even more cells of the region defined by block G3−G2, Stops appear at both minimal and maximal prosodic word boundaries in these two grammars, given high ranking INTENSITY≤3ω_{min}. The relative ranking of INTENSITY≤4ω_{min} and *PA determines which approximant category is optimal in the lowest prosodic boundary context:

(39)

G3		INT≤3 ω_{min}	INT≤4 ω_{min}	*PA	*TA
☞	a. $(((\text{tɾa.β̞a.xo})\omega_{min})\omega_{max})\varphi$ 7 57			*	
	b. $(((\text{tɾa.b̞a.xo})\omega_{min})\omega_{max})\varphi$ 7 47		*!		*
	c. $(((\text{tɾa.ba.xo})\omega_{min})\omega_{max})\varphi$ 7 37	*(!)	*(!)		
	d. $(((\text{mi(.β̞a.ɾi̯o})\omega_{min})\omega_{max})\varphi$ 7 57	*(!)	*(!)	*	
	e. $(((\text{mi(.b̞a.ɾi̯o})\omega_{min})\omega_{max})\varphi$ 7 47	*!			*
☞	f. $(((\text{mi(.ba.ɾi̯o})\omega_{min})\omega_{max})\varphi$ 7 37				
	h. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.β̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 57	*(!)	*(!)	*	
	i. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.b̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 47	*!			*
☞	j. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((\text{.ba.si.ko})\omega_{min})\omega_{max})\varphi$ 7 37				

(40)

G2		INT≤3ω_{min}	*PA	*TA
	a. (((tɾa.β̞a.xo)ω_{min})ω_{max})φ 7 57		*!	
☞	b. (((tɾa.b̞a.xo)ω_{min})ω_{max})φ 7 47			*
	c. (((tɾa.ba.xo)ω_{min})ω_{max})φ 7 37	*!		
	d. (((mi(.β̞a.ɾi̯o)ω_{min})ω_{max})φ 7 57	*(!)	*(!)	
	e. (((mi(.b̞a.ɾi̯o)ω_{min})ω_{max})φ 7 47	*!		*
☞	f. (((mi(.ba.ɾi̯o)ω_{min})ω_{max})φ 7 37			
	h. (((kuɾ.so)ω_{min})ω_{max}((.β̞a.si.ko)ω_{min})ω_{max})φ 7 57	*(!)	*(!)	
	i. (((kuɾ.so)ω_{min})ω_{max}((.b̞a.si.ko)ω_{min})ω_{max})φ 7 47	*!		*
☞	j. (((kuɾ.so)ω_{min})ω_{max}((.ba.si.ko)ω_{min})ω_{max})φ 7 37			

INTENSITY≤3ω_{min} rules out (39)d,e,h,i and (40)d,e,h,i because the target consonants do not drop to intensity level 3 or lower at the minimal prosodic word boundary. The optimal approximant allophone at the syllable level is determined by the other dominant constraint: INTENSITY≤4ω_{min} (39)a or *PA (40)b.

Finally, the strongest block is constituted by a single grammar, G1, in which the two high ranking segmental markedness constraints *PA and *TA rule out approximant allophones in all three prosodic contexts. In the final tableau in (41), prosodic structure above the syllable level is omitted from the candidates in order to allow enough space to include all of the dominated INTENSITY constraints on the lower stratum. Except for the absence of input forms, this tableau is similar to the master spreadsheet file that we constructed in Excel to serve as input to OTSoft

(Hayes et al., 2003) for the purpose of calculating the factorial typology. Each of the INTENSITY constraints shown here is crucially high ranked in at least one of the other nine grammars, as we have just illustrated above. In G1, however, enforcing segmental intensity thresholds across prosodic boundaries is no longer as important as avoiding approximant allophones altogether in (41)c,f,j.

(41)

G1	*PA	*TA	INT≤3φ	INT≤3ω_{max}	INT≤3ω_{min}	INT≤4φ	INT≤4ω_{max}	INT≤4ω_{min}
a. tɾa.β̞a.xo 757	*!							
b. tɾa.b̞a.xo 747		*!				*	*	*
☞ c. tɾa.ba.xo 737			*	*	*	*	*	*
d. mi.β̞a.ɾi̯o 757	*!				*			*
e. mi.b̞a.ɾi̯o 747		*!			*	*	*	
☞ f. mi.ba.ɾi̯o 737			*	*		*	*	
h. kuɾ.so.β̞a.si.ko 757	*!			*	*		*	*
i. kuɾ.so.b̞a.si.ko 747		*!		*	*	*		
☞ j. kuɾ.so.ba.si.ko 737			*			*		

The complete tableau in (41) contains all of the relevant markedness constraints and the violation marks they assign. This makes it possible to calculate the harmony, or relative well-formedness, of each [VCV] intensity contour as a function of prosodic boundary context, by counting up the number of violation marks in each candidate's row. A contour is relatively more harmonic if it has relatively fewer violations. Table 4.12 organizes the violation totals of each of the nine candidates in a 3-by-3 contingency table, with intensity contour by column and prosodic context by row. There is a grand total of 33 violation marks assigned to the entire candidate set. The values listed in the cells within each row and column make up a ratio consisting of three terms. Depending on the comparison being made, the ratios express the relative harmony of the intensity contours and can be interpreted as harmonic orderings of the output candidates in which the contours appear. For instance, intensity contour 757 incurs fewer overall violations than contours 747 and 737, as listed in the bottom row of the table: 9 vs. 12 vs. 12. The simplified ratio is 3:4:4. This ratio can be expressed as a harmonic ordering of candidates containing the three intensity contours, 757 > 747 = 737, where '>' means "relatively more harmonic than" and '=' means "equal in relative harmony to." This ordering expresses the generalization that, all things considered, a candidate that contains an intervocalic PA is slightly more harmonic than one containing an intervocalic TA or Stop, whereas candidates with the latter two are equivalent in relative harmony.

Table 4.12 Total violations of markedness constraints based on the cross-tabulation of prosodic domain levels by intensity contours

	Vβ̞V 757	Vb̥V 747	VbV 737	totals
(((V._V)ω_{min})ω_{max})φ	1	4	6	11
((V(._V)ω_{min})ω_{max})φ	3	4	4	11
(((V))ω_{max}((._V))ω_{max})φ	5	4	2	11
totals	9	12	12	33

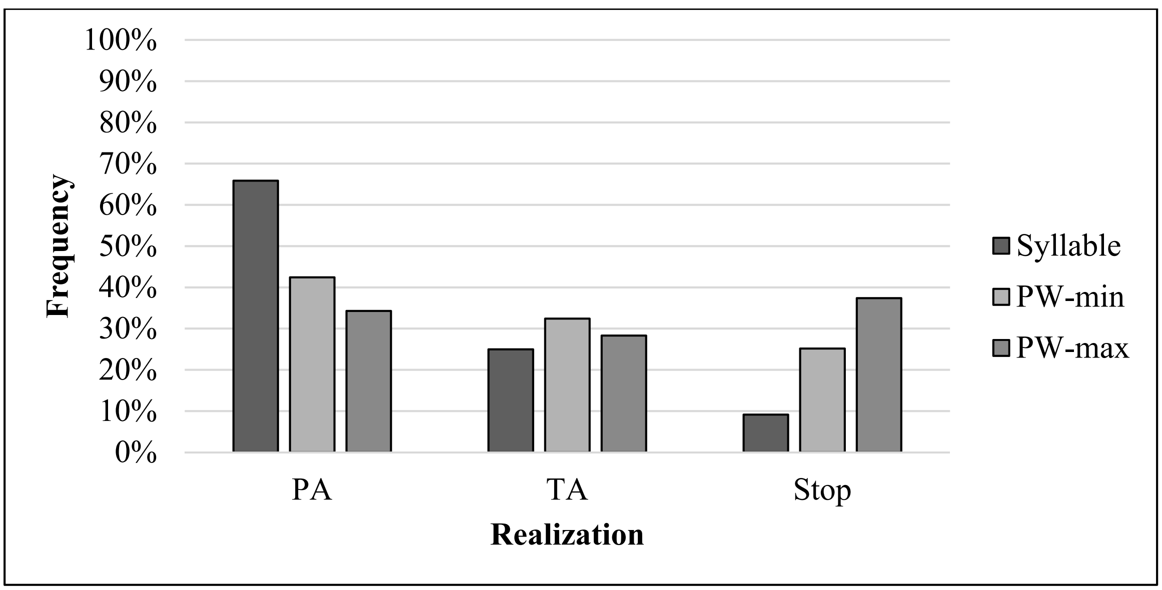
Three ratios are extracted from the columns of Table 4.12 and presented as relative harmonic orderings in Table 4.13. Intensity contours are denoted by the intervocalic target allophone, i.e. PA, TA, and Stop, and prosodic boundary contexts are denoted as syllable, PW-min, and PW-max. Several significant generalizations emerge. First, the orderings for PA and Stop are mirror images of each other. PAs are relatively more harmonic at the syllable boundary within the PW-min domain and relatively less harmonic at the PW-max boundary. Conversely, Stops are relatively more harmonic at the PW-max boundary and relatively less harmonic at the syllable boundary within the PW-min domain. In both cases, the PW-min boundary remains intermediate between syllable and PW-max with respect to the relative harmony of PAs and Stops. Second, TAs have relatively equivalent harmony at all three prosodic boundaries, which reflects their intermediate position between PAs and Stops with respect to relative intensity (see Table 4.10 in Section 4.5).

Table 4.13 Relative harmonic orderings of prosodic boundary contexts by allophone category

allophone	relative harmonic ordering				
PA	syllable	>	PW-min	>	PW-max
TA	syllable	=	PW-min	=	PW-max
Stop	PW-max	>	PW-min	>	syllable

The main effects reported for prosodic domain in Chapter 3 corroborate the relative harmonic orderings presented here. As shown again in Figure 3.3, the frequency of PAs decreases in statistically significant fashion as the boundary becomes higher in the prosodic hierarchy, which is in the same direction as the relative harmonic ordering for PAs in Table 4.13, syllable > PW-min > PW-max. The significant interaction between prosodic domain and (lack of) stress in the PA model (see Figure 3.6 of Chapter 3) confirms the same ordering even more clearly in unstressed syllables. There are no significant main effects or interactions involving prosodic domain for TAs, which reflects their relatively equivalent harmony at all three boundaries, syllable = PW-min = PW-max. Although falling short of statistical significance, most likely due to the imbalance of dependent variable categories across the data set, the trend for Stops is that they decrease in frequency as the boundary becomes lower in the prosodic hierarchy, which is in the same direction as the relative harmonic ordering for Stops: PW-max > PW-min > syllable. In the Stop model, the interaction between prosodic domain and phoneme is significant only for /d/ (see Figure 3.20 of Chapter 3), perhaps because coronals happen to have the most overall tokens.

Figure 4.5 Prosodic domain effects (repeated from Chapter 3)



Therefore, at the most general level, we can say that our experimental results confirm the predictions of our formal model regarding prosodic mediation effects in spirantization. This claim is based on the plausible assumption that the relative frequency of allophones in Figure 3.3 is positively correlated with their relative harmony in Table 4.13. Simply put, candidates that are relatively more harmonic should be attested at higher rates than those that are relatively less harmonic. But how exactly does the attested frequency variation emerge from the factorial typology of grammatical constraint rankings in Table 4.11?

We would like to propose that G5 corresponds to the "default grammar" that characterizes the majority of our participants: PAs are favored at the syllable boundary, TAs at PW-min, and Stops at PW-max. Minimal ranking fluctuations at evaluation time, either under experimental conditions or in more naturalistic settings, can skew these relative frequencies—but only in directions that are consistent with the thresholds established by INTENSITY constraints. For example, a re-ranking between INTENSITY$\leq 4\omega_{min}$ and *PA yields the G4 distribution, which differs minimally from G5 by switching PA to TA in the cell of the syllable boundary column. However, adding a TA in this cell entails adding a TA under the PW-min boundary column to the right, which means that an increase in TA frequency at the syllable boundary entails a corresponding increase at the PW-min boundary (assuming a balanced number of tokens representing both contexts). Another possible re-ranking, between INTENSITY$\leq 4\omega_{min}$ and INTENSITY$\leq 4\omega_{max}$, yields the G6 distribution, which switches TA to PA in the cell of the PW-min boundary column. Again, adding a PA in this cell entails adding a PA under the syllable boundary column to the left. Correspondingly, an increase in PA frequency at the PW-min boundary entails an increase at the syllable boundary (assuming a balanced number of overall tokens). On this view, fluctuations in constraint ranking lead to variation in the relative harmony of intensity contours, which in turn influences allophone frequencies at different prosodic boundary contexts, but never in a way that contravenes the stringency relationships that exist among INTENSITY constraints.

Having motivated a typology of spirantization as prosodically driven continuity lenition, we now turn to a discussion of phoneme, stress, and task effects and how they can be incorporated into the basic model.

4.7.1 Phoneme effects

As reported in Section 3.3.1 of Chapter 3, the analysis of main effects reveals that non-dorsal /b/ and /d/ are more likely than dorsal /g/ to be pronounced as a PA and less likely than dorsal /g/ to be pronounced as a TA. No statistically significant main effects are found for Stops. For Mexican Spanish, Lavoie (2001) measures [ɣ̞] as the least intense of the three approximants, and /g/ is reported to be less likely to approximantize than non-dorsal voiced stops in a range of different Spanish varieties. What is the basis of this asymmetry between the dorsal and non-dorsals?

A straightforward articulatory explanation is available. If the tongue dorsum has more mass than either the lips or the tongue tip, then moving the tongue dorsum should take more time than moving either of the other two articulators, assuming the relative distance of movement is held constant. Furthermore, the tongue dorsum is also the primary articulator of vowels, which involve relatively slower movements and longer durations as compared to consonants. We propose that, at least for the class of voiced stops, dorsal /g/ has relatively greater *inherent intensity* than non-dorsal /b/ and /d/, given the inherent differences in articulator size and movement speed. The idea is that /g/ is less susceptible to lenition pressures than /b/ and /d/ because /g/ is already more intense to begin with. This asymmetry can be captured by a slight modification of our alignment of Rao's (2014, 2015) dependent variable categories to Katz's (2016) scale of relative consonantal intensity, first presented in Table 4.10. As shown in Table 4.14, we propose to shift the entire dorsal series upward by one level, such that (i) PA [ɣ̞] ranks the same as glides at level 6, (ii) TA [g̞] ranks the same as PAs [β̞] and [ð̞], and (iii) Stop [g] ranks the same as TAs [d̞] and [g̞].

Table 4.14 Relatively greater inherent intensity of voiced dorsal stops

relative consonantal intensity (Katz 2016)			dependent variable categories (Rao 2015)		
J	glide	6			ɣ̞
R	tap	5	β̞	ð̞	g̞
Z	voiced continuant	4	b̞	d̞	g
D	voiced stop	3	b	d	↑
S	voiceless continuant	2	f	s	x
T	voiceless stop	1	p	t	k

The geometric consequence of increasing the intensity index of dorsals by one level is that the cells occupied by the nine categories no longer form a square but an irregular octagon. The analytical consequence of this formal change is that it now becomes possible for a given constraint ranking to favor stronger dorsal realizations at the same time as weaker non-dorsal realizations. We illustrate this result in grammar G5, using the examples *trabajo* 'job', *pedazo* 'piece', and *gigante* 'giant' for the syllable boundary context (42), *mi barrio* 'my neighborhood', *la dama* 'the lady', and *la gala* 'the gala' for PW-min (43), and *curso básico* 'basic course', *veo damas* 'I see ladies', and *mismo gato* 'same cat' for PW-max (44):

(42)

G5		INT≤3 *ωmax*	INT≤4 *ωmin*	*PA	*TA
☞	a. (((tɾa.β̞a.xo)ωmin)ωmax)φ 7 57			*	
	b. (((tɾa.b̞a.xo)ωmin)ωmax)φ 7 47		*!		*
	c. (((tɾa.ba.xo)ωmin)ωmax)φ 7 37	*(!)	*(!)		
☞	d. (((pe.ð̞a.so)ωmin)ωmax)φ 7 57			*	
	e. (((pe.d̞a.so)ωmin)ωmax)φ 7 47		*!		*
	f. (((pe.da.so)ωmin)ωmax)φ 7 37	*(!)	*(!)		
☞	g. (((xi.ɣ̞an.te)ωmin)ωmax)φ 7 67			*	
☞	h. (((xi.g̞an.te)ωmin)ωmax)φ 7 57				*
	i. (((xi.gan.te)ωmin)ωmax)φ 7 47		*!		

(43)

	G5	Int≤3 ω_{max}	Int≤4 ω_{min}	*PA	*TA
	a. (((mi(.β̝a.ri̯o)ω_{min})ω_{max})φ 7 57		*!	*	
☞	b. (((mi(.b̝a.ri̯o)ω_{min})ω_{max})φ 7 47				*
	c. (((mi(.ba.ri̯o)ω_{min})ω_{max})φ 7 37	*!			
	d. (((la(.ð̝a.ma)ω_{min})ω_{max})φ 7 57		*!	*	
☞	e. (((la(.d̝a.ma)ω_{min})ω_{max})φ 7 47				*
	f. (((la(.da.ma)ω_{min})ω_{max})φ 7 37	*!			
	g. (((la(.ɣ̝a.la)ω_{min})ω_{max})φ 7 67		*!	*	
	h. (((la(.g̝a.la)ω_{min})ω_{max})φ 7 57		*!		*
☞	i. (((la(.ga.la)ω_{min})ω_{max})φ 7 47				

(44) G5		INT≤3 ω_{max}	INT≤4 ω_{min}	*PA	*TA
	a. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((.\text{β̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 57	*(!)	*(!)	*	
	b. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((.\text{b̞a.si.ko})\omega_{min})\omega_{max})\varphi$ 7 47	*!			*
☞	c. $(((\text{kuɾ.so})\omega_{min})\omega_{max}((.\text{ba.si.ko})\omega_{min})\omega_{max})\varphi$ 7 37				
	d. $(((\text{be.o})\omega_{min})\omega_{max}((.\text{ð̞a.mas})\omega_{min})\omega_{max})\varphi$ 7 57	*(!)	*(!)	*	
	e. $(((\text{be.o})\omega_{min})\omega_{max}((.\text{d̞a.mas})\omega_{min})\omega_{max})\varphi$ 7 47	*!			*
☞	f. $(((\text{be.o})\omega_{min})\omega_{max}((.\text{da.mas})\omega_{min})\omega_{max})\varphi$ 7 37				
	g. $(((\text{miz.mo})\omega_{min})\omega_{max}((.\text{ɣ̞a.to})\omega_{min})\omega_{max})\varphi$ 7 67	*(!)	*(!)	*	
	h. $(((\text{miz.mo})\omega_{min})\omega_{max}((.\text{g̞a.to})\omega_{min})\omega_{max})\varphi$ 7 57	*(!)	*(!)		*
☞	i. $(((\text{miz.mo})\omega_{min})\omega_{max}((.\text{ga.to})\omega_{min})\omega_{max})\varphi$ 7 47	*			

Given the modified intensity indices in Table 4.14, G5 now treats dorsals differently than non-dorsals in each of the prosodic boundary contexts. At the syllable boundary within the PW-min domain, the PA realization is optimal for the bilabial (42)a and the coronal (42)d, but the dorsal may be pronounced as a PA (42)g or TA(42)h, assuming *PA and *TA remain unranked with respect to each other. At the PW-min boundary, the TA realization is optimal for the bilabial (43)b and the coronal (43)e, but the dorsal must be realized as a Stop (43)i. Finally, at the PW-max boundary, the Stop realization is optimal for all three phonemes (44)c,f,i.

Recall from the discussion of BOUNDARY-DISRUPTION constraints in Section 4.4 that in Spanish, high ranking IDENT(voice) prevents input intervocalic voiceless stops from mapping to output voiced approximants, as shown in (28)a vs. (28)c. Faithfulness to voicing also places limits on the fortition of dorsal voiced obstruents. Although the 727 contour created by the devoicing of PW-max-initial /g/ satisfies INTENSITY≤3ω_{max} in (45)d, the /g/→[k] mapping fatally violates IDENT(voice). The same constraint also prevents devoicing of /ɣ̥/→[k] in (46)d.

(45)

	/mismo gato/	IDENT(voice)	INT≤3ω_{max}	INT≤4ω_{min}	IDENT(cont)
	a. (((miz.mo)ω_{min})ω_{max}((.ɣ̥a.to)ω_{min})ω_{max})φ 7 67		*(!)	*(!)	*
	b. (((miz.mo)ω_{min})ω_{max}((.g̥a.to)ω_{min})ω_{max})φ 7 57		*(!)	*(!)	*
☞	c. (((miz.mo)ω_{min})ω_{max}((.ga.to)ω_{min})ω_{max})φ 7 47		*		
	d. (((miz.mo)ω_{min})ω_{max}((.ka.to)ω_{min})ω_{max})φ 7 27	*!			

(46)

	/mismo ɣ̥ato/	IDENT(voice)	INT≤3ω_{max}	INT≤4ω_{min}	IDENT(cont)
	a. (((miz.mo)ω_{min})ω_{max}((.ɣ̥a.to)ω_{min})ω_{max})φ 7 67		*(!)	*(!)	
	b. (((miz.mo)ω_{min})ω_{max}((.g̥a.to)ω_{min})ω_{max})φ 7 57		*(!)	*(!)	
☞	c. (((miz.mo)ω_{min})ω_{max}((.ga.to)ω_{min})ω_{max})φ 7 47		*		*
	d. (((miz.mo)ω_{min})ω_{max}((.ka.to)ω_{min})ω_{max})φ 7 27	*!			*

The inclusion of IDENT(cont) in these two tableaux allows us to demonstrate convincingly that our analysis is fully compliant with ROTB. The inputs contain a potential contrast between

Stop /g/ (45) and PA /ɣ̞/ (46) in word-initial position. The change in violations assigned by faithfulness to continuancy has no bearing on the selection of the optimal candidate. The input contrast is obligatorily neutralized to Stop [g] in both (45)c and (46)c, and the same result would obtain if the input were to contain a TA /g̞/.

4.7.2 Stress effects

In Section 3.3.2 of Chapter 3, we discussed the main effect of Stress, whereby PAs are more likely to appear in unstressed than stressed syllables and, conversely, TAs are more likely in stressed than unstressed syllables. Like TAs, Stops are more frequent in stressed syllables, although the trend fails to reach statistical significance. Stress is treated as an independent variable separate from prosodic domain in the methodological design of Chapter 2 as well as in most other phonetic studies. From a phonological perspective, however, it is possible to model stress effects by appealing to prosodic foot structure. In particular, we assume that the initial onset consonant of a stressed syllable is also initial in a trochee, the default foot in Spanish. The initial onset consonant of an unstressed syllable is *non-foot-initial,* either because the onset is foot-medial or because the syllable containing the onset is unfooted.

Tableau (47) demonstrates how this works, using a hypothetical ranking and three candidate words that differ in the position of the target consonant with respect to the stressed syllable, *trabajo* 'job', *sábana* 'sheet', and *grabadora* 'recorder'. INTENSITY$\leq 3\omega_{max}$ rules out the Stops in (47)c,f,i. The Stress effect follows from the activity of INTENSITY$\leq 4\Sigma$, which selects the PAs in (47)d,g because the TAs in (47)e,h are too disruptive when non-foot-initial; at the same time, it also selects the TA in (47)b because the PA in (47)a is not disruptive enough when aligned with the left edge of the stress foot.

(47)		INT≤3ω_{max}	INT≤4Σ	*PA	*TA
	a. (((tɾa(ˈ.β̞a.xo)Σ)ω$_{min}$)ω$_{max}$)φ 7 57		*!	*	
☞	b. (((tɾa(ˈ.b̞a.xo)Σ)ω$_{min}$)ω$_{max}$)φ 7 47				*
	c. (((tɾa(ˈ.ba.xo)Σ)ω$_{min}$)ω$_{max}$)φ 7 37	*!			
☞	d. ((((ˈsa.β̞a)Σ.na)ω$_{min}$)ω$_{max}$)φ 7 57			*	
	e. ((((ˈsa.b̞a)Σ.na)ω$_{min}$)ω$_{max}$)φ 7 47		*!		*
	f. ((((ˈsa.ba)Σ.na)ω$_{min}$)ω$_{max}$)φ 7 37	*(!)	*(!)		
☞	g. (((gɾa.β̞a(ˈ.d̞o.ɾa)Σ)ω$_{min}$)ω$_{max}$)φ 7 57			*	
	h. (((gɾa.b̞a.(ˈ.d̞o.ɾa)Σ)ω$_{min}$)ω$_{max}$)φ 7 47		*!		*
	i. (((gɾa.ba.(ˈ.d̞o.ɾa)Σ)ω$_{min}$)ω$_{max}$)φ 7 37	*(!)	*(!)		

Adding INTENSITY≤3*Σ* and INTENSITY≤4*Σ* to the six constraints in (30) would no doubt complexify the basic model in Table 4.11 by introducing a new column for the foot domain, as well as new permutations of allophone categories within an expanded typological subspace. Here we have shown how such an approach can formalize stress effects as the result of boundary disruptive fortition at the left edge of a trochaic foot. Further research is necessary to explore the broader typological implications of this approach.

4.7.3 Task effects

In Section 3.3.5 of Chapter 3, we saw that task type is a significant predictor of the distribution of PAs, which are more frequent in the conversation than the reading task. Neither the TA nor Stop model shows any main effect of task type, although the frequencies of allophones both trend in the expected direction, i.e. higher in the reading than the conversation task. To what aspect of our formal analysis are task effects attributable? Similar to our proposed explanation of variation in allophone frequency across different prosodic boundaries, we argue that minimal fluctuations in constraint ranking can skew the relative frequencies of allophones away from the default "baseline" that is grammar G5. Speakers move upward into the typological space as the speech style becomes more careful, thereby increasing the harmony and, thus, frequency of the relatively stronger TA and Stop allophones. Downward movement has the opposite effect as speech becomes more casual, leading to an increase in the harmony and frequency of the relatively weaker PA allophones.

4.8 Continuity lenition beyond heritage Spanish

Our analysis of prosodically driven continuity lenition in Colombian heritage Spanish makes broader predictions that are empirically supported by data and descriptions from elsewhere in Ibero-Romance, namely Judeo-Spanish (Hualde, 2013; Hualde & Şaul, 2011; Quintana, 2006). Varieties spoken around Bosnia, Serbia, Croatia, Romania, Bulgaria, and Israel lack the continuant allophones of /b, d, g/ in Hispanic lexical items. In these dialects, voiced stops appear in all contexts, even after a vowel in word-medial position, e.g. [ˈde.du] 'finger', [ˈsi̯e.gu] 'blind'. A different distribution is found in Turkish varieties. In Istanbul Judeo-Spanish, intervocalic approximants surface word-medially, as illustrated for coronal /d/ (48)a, but stops surface word-initially after the non-cohering prefix /a–/ (48)b and after the final vowel of a preceding word (48)c:

(48)	a.	[se.fa.ɾaˈ.ð̞i]	'Sephardic'		
		[maˈ.ɾi.ð̞o]	'husband'		
	b.	[a.dulˈ.saɾ]	'to sweeten'	cf. [‖ˈdul.se]	'sweet'
		[a.delˈ.ɣ̞a.saɾ]	'to become thin'	cf. [‖delˈ.ɣ̞a.ð̞o]	'thin'
	c.	[el ˈai̯.ɾe del ˈnoɾ.te]	'the north wind'	cf. [‖del]	'of the'
		[le ˈdi.ʃo]	's/he told him'	cf. [‖ˈdi.ʃo]	'told'

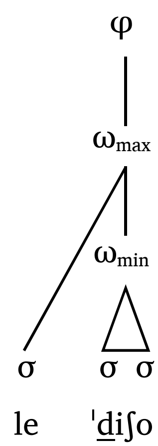
A comparison with the non-prefixed forms in (48)b and with postpausal pronunciations of the /d/-initial words in (48)c reveals that spirantization is blocked when the intervocalic target consonant is initial in the minimal or maximal prosodic word, unlike in word-medial position (48)a. By contrast, intervocalic spirantization applies word-initially as well as word-medially in all varieties of contemporary monolingual Spanish, e.g. [el ˈai̯.ɾe ð̞el ˈnoɾ.te] and [le ˈð̞i.xo].

A plausible explanation for the lack of continuant allophones of /b, d, g/ in the Judeo-Spanish dialects of the Balkans is contact with co-territorial languages, such as Slavic in the Balkan regions and Arabic in Jerusalem and Hebron, that do not possess the corresponding spirant approximants (Quintana, 2006: 88). We suggest a possible formal implementation of this account along the following lines. In the historical contact situation, language learners would have been exposed to a greater amount of positive evidence in support of unweakened voiced stops appearing between vowels. A possible outcome may have involved convergence towards the ranking of grammar G1 in Table 4.11, in which the markedness constraints against pure and tense approximants are ranked the highest, thereby requiring voiced stops across the board. Furthermore, the typology demarcates intensity thresholds that define potential pathways of change, as they may arise in situations of language contact, or even in natural, internal sound change. At present, we simply lack the type of detailed, quantitative data that would be necessary to verify these possible diachronic pathways.

Hualde (2013: 248-249) offers a diachronic account of the blocking of word-initial spirantization in Istanbul Judeo-Spanish. He proposes that, at an earlier common stage, intervocalic spirantization applied across the board, regardless of word boundaries, in both Sephardic and non-Sephardic Peninsular Spanish. At a later stage in Judeo-Spanish, postpausal stops were analogically extended from phrase-initial to phrase-medial word-initial contexts. For example, [‖ˈdi.ʃo] would have alternated with [le ˈð̞i.ʃo] early on, while Judeo-Spanish speakers at some point opted for the postpausal pronunciation as the model for *all* word-initial voiced obstruents. We offer a simpler, prosodically based account of the word-initial blocking effect that does not require analogy between surface forms, or, as commonly implemented in OT, output-output correspondence constraints powerful enough to see across derivations. In Figure 4.6, the arrows indicate the highest domain of the prosodic tree in which /d/ is the initial segment, the minimal prosodic word in (a) vs. the maximal prosodic word in (b). Given these prosodic representations, either grammar G2 or G3 is sufficient to ensure voiced stops at both the minimal and maximal word boundaries. If the non-cohering prefix in words like [a.dulˈ.saɾ] is treated as a prosodic proclitic, then a recursive representation such as (((a(.d̲ulˈ.saɾ)$_{\omega_{min}}$)$_{\omega_{max}}$)$_{\varphi}$ would also favor a voiced stop pronunciation in both G2 and G3.

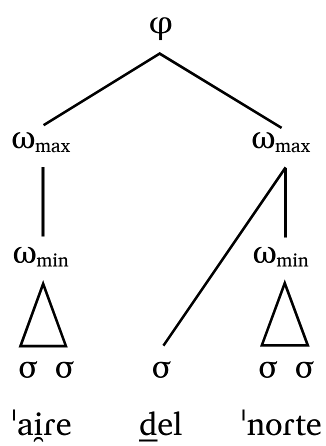
Figure 4.6 Prosodic representations of Judeo-Spanish [le ˈdi.ʃo] ‘s/he told him’ (a) and [ˈai̯.ɾe del ˈnoɾ.te] ‘north wind’ (b)

(a)



(((le(ˈ.d̲i.ʃo)ωmin)ωmax)φ

(b)



(((ˈai̯.ɾe)ωmin)ωmax(.d̲el(ˈ.noɾ.te)ωmin)ωmax)φ

The evidence from diatopic variation in Judeo-Spanish provides strong empirical support for the distributions of voiced stop allophones predicted by grammars G1–G3. The surface patterns generated by G4–G6 stand as predictions for likely pathways of change *en route* to a more stable, stop dominant grammar. As explained near the end of Section 4.7, if minimal fluctuations in constraint ranking are assumed to occur at evaluation time, either in laboratory settings or in spontaneous conversation, then it becomes possible to model the effects of phoneme, stress, prosodic domain, and task type that we find in our participants’ speech production data.

Our factorial typology in Table 4.11 also provides an alternative theoretical account of the acquisition pathways reported by Zampini (1997, 1998) and Cabrelli Amaro (2017) for L2 Spanish learners. On the one hand, Zampini's claim that postvocalic spirantization is acquired earlier in smaller prosodic domains is directly captured as a progression across grammar blocks: (i) G1 allows no spirantization, (ii) G2–G2 restrict spirantization to word-medial position, (iii) G4–G6 extend spirantization from medial to initial position in the minimal prosodic word, and (iv) G7–G10 allow spirantization in all three prosodic domains. On the other hand, Cabrelli Amaro's finding that intermediate and advanced L2 learners spirantize to the same degree across both the minimal and maximal prosodic word boundary suggests that her non-beginning L2 learners do not vary much from ranking G8. Native speakers of the control group presumably favor variation between rankings G9 and G10.

Beyond the novel data and generalizations from Colombian heritage Spanish presented in this dissertation, further laboratory evidence will be required to confirm the gradient PA ~ TA alternations that are predicted by the "weakest" block of grammars, G7–G10. Few if any prior studies of Spanish spirantization and other related processes have ventured beyond the word-level context. According to Bonet (2020):

> "most studies on nasal assimilation and spirantization (also glide formation) concentrate on the properties of the processes themselves, rather than the syntactic contexts in which they can apply. But a question that needs to be addressed is whether the contextual segment (a following consonant in nasal assimilation, *or a previous vowel, for example, in spirantization) can be found in any syntactic configuration or whether the depth of syntactic embedding matters* [my italics—CJL]" (324).

More research is needed to determine the extent of prosodic mediation effects on spirantization, in Spanish and in other Ibero-Romance languages, especially at higher levels of the prosodic hierarchy, and including a range of segmental and stress contexts. Several recent works have fruitfully pursued this type of experimental approach to preconsonantal sibilant voicing, e.g. *isla* [ˈiz.la] 'island', *tres limones* [ˈtɾez liˈ.mo.nes] 'three lemons', across different Spanish varieties (Schmidt & Willis, 2011; Campos-Astorkiza, 2014, 2015, 2019; Sedó et al., 2020; among others). The general finding is that voicing of /s/ before a voiced consonant is not categorical but gradient and influenced by prosodic position. Voicing affects more of the sibilant's constriction period and applies at higher rates within the intonation phrase (IP) than across the IP boundary, and more so at the beginning of sentences than at the end. Campos-Astorkiza (2019) proposes an Articulatory Phonology account in which prosodic or *π-gestures* located at domain boundaries have the effect of slowing down the articulation of nearby consonant and vowel gestures (Byrd et al., 2000; Byrd & Saltzman, 2003). This reduces the amount of temporal overlap between the glottal gestures of the sibilant and the adjacent voiced consonant, thereby decreasing the likelihood and degree of regressive voicing assimilation as the intervening boundary becomes higher in the prosodic hierarchy.

> "The gradient effect of prosodic boundaries suggests that degree, rather than presence or absence, of assimilation may function as a cue to the occurrence of an IP boundary and be of relevance, for example, where there is no pause between the two phrases. Furthermore, given the π-gesture model we expect different prosodic boundaries to have gradual effects on the amount of voicing, according to their strength. This is in fact a fruitful direction for future research, since exploring the interaction between prosodic boundaries and voicing assimilation will allow us not

> only to refine our understanding of the process but also to better characterize prosodic structure in Spanish" (Campos-Astorkiza, 2019: 272).

Sedó et al. (2020) argue that what appears to be a regressive assimilation is actually a progressive continuation of voicing from a preceding vowel into the following coda sibilant, which can be inhibited under the right aerodynamic conditions. Further corroborating the influence of sentence-level structure on sibilant voicing, they argue that

> "voicing of /s/ can generally be viewed as a lenition process, but that this mechanism can be inhibited when in contact or conflict with devoicing in sentence-final position. In sentence final position voicing may not be the traditional reduced or lenited outcome due to additional constraints of potential sentence-final devoicing, and/or a reduction in airflow at the end of an utterance" (206).

A fully comprehensive account of different continuity lenition processes in Spanish remains to be worked out, but the prospects seem promising for developing such an approach to alternations in voicing, which is no longer phonologically contrastive in the contemporary language.

4.9 Conclusion

This chapter has pursued a novel approach to intervocalic spirantization, based on Katz's (2016) perceptually based theory of continuity lenition and boundary disruption. A review of previous laboratory studies motivated a formal scale of relative consonantal intensity, which in turn formed the basis of INTENSITY constraints. A basic typological model of prosodically driven continuity lenition was developed and then extended to account for the phoneme, stress, and task effects reported in Chapter 3. The typology also encompasses diatopic variation in Judeo-Spanish, and invites further laboratory research into continuity lenition effects in Spanish. If the approach pursued in this chapter is on the right track, as recent experimental studies by Katz and colleagues and by Broś et al. (2021) seem to suggest, then it becomes even more urgent to pursue a listener-based theory of consonant lenition capable of transcending speaker-based accounts that appeal to articulatory effort.

CHAPTER 5: CONCLUSIONS

5.1 Introduction

This chapter will review the main points of the dissertation. Section 5.2 returns to the research questions posited in Chapter 1. Section 5.3 addresses the implications of the results of the study. Finally, Section 5.4 presents the limitations, and Section 5.5 suggests future directions for this line of research.

5.2 Research questions

The research questions guiding the direction of this study are repeated here from Chapter 1, followed by a summary of the results from the previous chapters.

5.2.1 How do U.S. Spanish speakers of Colombian heritage produce intervocalic voiced stops (/b, d, g/)?

The overall distribution of /b, d, g/ throughout the data set shows a preference for the most lenited realization, PA, over TA and Stop for thirteen of the participants. Individual variation in the number of tokens between the two tasks makes direct comparisons among participants difficult, but only three participants stray from this pattern. One participant produces more TAs than PAs and Stops, and two participants produce more Stops than TAs and PAs. These three individuals also produce the fewest number of tokens in the conversation task, meaning that more data is needed to understand their divergence from the pattern found among the other participants who generally prefer PAs over TAs and Stops.

5.2.2 How does their pronunciation of postvocalic voiced stops vary as a function of the following variables: phoneme, syllable stress, prosodic domain, and task type?

The results for phoneme effect find /d/ and /b/ leniting to PAs more than /g/. While not a main effect, /g/ surfaces more frequently as a Stop than the bilabial and coronal do, and more frequently across all realizations as a TA. This confirms the initial hypothesis that the dorsal consonant patterns differently than both the bilabial and coronal consonants. Syllable stress is a significant predictor of lenition, with stressed syllables inhibiting lenition beyond the word-medial position and unstressed syllables facilitating lenition asymmetrically across prosodic domains. For the prosodic domain variable within the PA model, lenition is most likely in syllable-initial position within the minimal prosodic word, less likely in initial position of the minimal prosodic word, and least likely initially in the maximal prosodic word. Finally, evidence from this study suggests that task type has a significant effect with casual speech favoring lenition to PAs in the conversation task.

5.2.3 What social factors in a speaker's linguistic background affect individual variation in voiced stop lenition?

While previous studies report a significant effect for social factors such as order of language acquisition and family generation (Amengual, 2019; Blair & Lease, 2021), the present study finds neither of these factors to be significant in mediating voiced stop lenition. The factor of speech community, either New Jersey or Miami, was also insignificant.

5.2.4 How can patterns of voiced stop lenition in Colombian heritage Spanish be modeled in a phonetically-based Optimality Theory framework?

The OT analysis presented in Chapter 4 makes a novel contribution to our understanding of how continuity lenition (Katz 2016) operates across the lower levels of the prosodic hierarchy. A more streamlined and slightly reformulated version of Katz's BOUNDARY-DISRUPTION constraint schema singles out intensity as the primary acoustic correlate of a segment's articulatory openness. We propose a basic model of prosodically driven continuity lenition, predicted by a factorial typology based on segmental markedness constraints and a stringency hierarchy of INTENSITY constraints. The model accounts for gradient yet systematic variation among three phonetic categories of consonant strength as a function of prosodic boundary level. The typology not only captures implicational generalizations about Colombian heritage Spanish but also makes testable predictions about possible patterns of variation, some of which are corroborated by spirantization patterns attested in the Judeo-Spanish diaspora. An OT account of spirantization as continuity lenition avoids the drawbacks of positional faithfulness (Cabrelli Amaro, 2017; Kingston, 2008) with respect to ROTB, and it avoids the incorrect prediction that continuancy contrasts should be subject to positional neutralization in some languages. Furthermore, a perception-based approach to spirantization moves beyond previous analyses of continuancy assimilation or stricture reduction by recognizing the crucial role of the listener in the speech chain. Our phonetically-based OT analysis adds to a growing body of work (Broś et al., 2021; Harper, 2014; Katz, 2016; Katz & Fricke, 2018; Katz & Moore, 2021; Keating, 2006; Kingston, 2008) seeking to flip the traditional narrative that consonantal weakening is primarily a speaker-based phenomenon driven by effort minimization.

5.3 Implications

Methodologically, the present study includes both careful and casual speech from an understudied variety of U.S. Spanish spoken by heritage speakers of Colombian descent. Moreover, it includes participants outside of a typical university setting, which remains the main source of current data in heritage Spanish language research.

The application of the OT framework to a heritage Spanish data set demonstrates the need to expand theoretical analyses to bilingual varieties. Typically, the use of either monolingual or learner data does not address the bilingual context of heritage speakers. The analysis proposed in Chapter 4 demonstrates that this variety can be accounted for within the same framework as non-heritage varieties of Spanish. This further confirms the call from Rao (2020) for more theoretical analyses of data from different groups of heritage speakers in order to promote a more comprehensive body of research into the phonological grammars of these varieties.

5.4 Limitations

There are various limitations to this study that can be motives for future research. First, by expanding the data set with more participants in a more stratified manner, it would be easier to answer more sociolinguistic questions relating to generation, age and order of language acquisition, speech community, individual language practices, etc.

The statistical significance between the reading task and conversation task types furthers the discussion on casual vs. careful speech. While phonetic realizations in the reading task were relatively evenly distributed across the linguistic variables, the distribution of these tokens in the conversation task varied among individual speakers. A solution for future studies would be longer or multiple recordings of casual speech from the same participants to widen the pool of tokens from which to randomly select for a stratified sample across all the variables that are being controlled for in the reading task.

5.5 Future directions

Given the limitations discussed in the previous section, there are various ways to expand upon this research. To start, adding to the data with more participants will help strengthen our understanding of the sociolinguistic factors involved. Amengual (2019) finds a distinction in production patterns between sequential and simultaneous bilinguals among his twenty heritage speakers. Blair and Lease (2021) report family generation be a significant social factor conditioning variation in spirantization across four generations of heritage speakers in the western U.S. With the majority of the population of second-generation Colombians under the age of 18, as of 2015, the expansion of the variable of generation to the fourth generation or beyond will take more time compared to other, more historically established Spanish speaking communities in the U.S. (Migration Policy Institute, 2015).

Many of the phonetic studies (Blair & Lease, 2021; Carrasco, 2008; Eddington, 2011; among others) include preceding and/or following vowel as a linguistic variable. The present study controls for the following vowel /a/ in the reading task stimuli but does not account for this variable in the statistical analyses. Including adjacent vowel height as an independent variable would allow further evaluation of Kirchner's (1998) Aperture Conditioning Generalization in (14), according to which voiced stops should be more likely to lenite when adjacent to vowels of greater articulatory openness.

Finally, more psycholinguistic experimentation on speech perception is necessary to test the claim that continuity lenition is listener-based. Recent studies by Katz and Fricke (2018) and

Katz and Moore (2021) use an artificial language learning and word segmentation paradigm to find that the pattern of initial stops vs. medial continuants facilitates the perception of word boundaries by American English listeners. There is a need for similar perceptual studies on Spanish, with listeners from a range of different dialects, in order to determine the extent to which alternations in segmental intensity make word boundaries easier to identify in running speech.

APPENDIX A: READING TASK STIMULI

Token	Phoneme	Stress	Syllables	Domain
ca**b**allo	b	stressed	3	syllable
tra**b**ajo	b	stressed	3	syllable
sá**b**ana	b	unstressed	3	syllable
gra**b**adora	b	unstressed	4	syllable
pe**d**azo	d	stressed	3	syllable
agra**d**able	d	stressed	4	syllable
a**d**apción	d	unstressed	3	syllable
na**d**ador	d	unstressed	3	syllable
abo**g**ada	g	stressed	4	syllable
gi**g**ante	g	stressed	3	syllable
hí**g**ado	g	unstressed	3	syllable
obli**g**ación	g	unstressed	4	syllable
mi **b**arrio	b	stressed	4	PWmin
lo **b**ásico	b	stressed	4	PWmin
la **b**allena	b	unstressed	4	PWmin
su **b**andera	b	unstressed	3	PWmin
su **d**ado	d	stressed	3	PWmin
la **d**ama	d	stressed	3	PWmin
lo **d**añino	d	unstressed	4	PWmin
la **d**anesa	d	unstressed	4	PWmin
mi **g**ato	g	stressed	3	PWmin
la **g**ala	g	stressed	3	PWmin
su **g**anancia	g	unstressed	4	PWmin
la **g**allina	g	unstressed	4	PWmin
gana la **b**atalla	b	unstressed	6	PWmin
es un curso **b**ásico	b	stressed	7	PWmax
no tengo **b**arcos	b	stressed	5	PWmax
me quiero **b**ajar	b	unstressed	5	PWmax
necesito **d**arme cuenta	d	stressed	8	PWmax
no veo **d**amas	d	stressed	5	PWmax
no puedo **d**añarme	d	unstressed	6	PWmax
es una linda **d**anesa	d	unstressed	8	PWmax
no tengo **g**anas	g	stressed	5	PWmax
es el mismo **g**ato	g	stressed	6	PWmax
le puede **g**arantizar	g	unstressed	7	PWmax
una buena **g**arantía	g	unstressed	8	PWmax

APPENDIX B: CONVERSATION QUESTIONS

Información demográfica

1. ¿Dónde nació Ud.?
2. ¿En qué año?
3. ¿Dónde fue a la primaria? ¿Secundaria? ¿Universidad?
4. ¿Dónde fue el primer lugar en que vivió?
5. ¿Y dónde vivió después?
6. ¿Dónde vive ahora? ¿Le gusta? ¿Por qué?
7. ¿Hace cuánto tiempo que Ud. vive aquí?
8. ¿Dónde nacieron sus padres? ¿y abuelos?
9. ¿Dónde se criaron?
10. ¿Fueron al colegio? ¿Dónde? ¿Hasta cuándo?
11. ¿A qué se dedican? ¿Dedicaron?
12. ¿Por qué se mudaron sus padres / sus abuelos / sus antepasados aquí?
13. ¿Se acuerda Ud. de oír historias sobre cómo su familia llegó a los Estados Unidos?
14. ¿Está casado/a? ¿Su esposa/o, de dónde es? ¿Qué idioma habla? ¿Dónde se conocieron?
15. ¿Tiene hijos? ¿hermanos/as?
16. ¿Tiene familia en Colombia? ¿Dónde?
17. ¿Visita a su familia a menudo?
18. ¿Qué le gusta hacer cuando va a Colombia?
19. ¿Ellos vienen a visitarle a menudo?
20. ¿Qué les gusta hacer cuando vienen a Florida / New Jersey?

Vecindario

1. ¿La mayoría de sus amigos viven por aquí, en este vecindario, o más lejos?
2. ¿Los residentes por aquí se ayudan el uno al otro?
3. Si Ud. necesita ayuda, ¿a quién se la pide?
4. ¿Qué cosas le gustan de este vecindario/ciudad?
5. ¿Algo le ha pasado que le hiciera pensar en mudarse de aquí?
6. ¿Hay alguien por aquí con quien Ud. se junte para socializar? ¿Qué cosas hacen juntos?
7. ¿De dónde es la gente que vive aquí?
8. ¿En dónde se juntan fuera de la casa?
9. En Latino América es muy común que la gente se visite sin anunciarlo, o sea, pasan por la casa de uno no más. ¿Le gusta esta manera de vivir?
10. ¿Se encuentra buena comida en este barrio? ¿Dónde?

Niñez

1. ¿Cómo ha cambiado la vida para los niños / adolescentes desde que Ud. se crio?
2. ¿Había alguna regla de a qué hora por la noche tenía que regresar a casa?
3. ¿Qué le pasa/pasaba si se queda/ba fuera demasiado tarde?
4. ¿Alguna vez le echaron la culpa por algo que no hizo?
5. ¿Puede/Podía hablar con sus padres cuando se mete/metía en problemas?
6. ¿Piensa que la vida de los niños hoy en día es más fácil o difícil que en el pasado?

7. ¿Qué piensa Ud. que son las diferencias más salientes entre personas mayores y jóvenes hoy en día?
8. ¿Cuáles eran algunos juegos que Ud. jugaba después de la escuela? ¿Cómo se jugaban?
9. ¿A qué edad entró Ud. en la escuela? ¿A los 6 años? ¿A los 4?
10. ¿Tenía algún maestro o alguna maestra que fuera muy difícil?

Trabajo

1. ¿Ahora tiene Ud. trabajo? ¿Qué hace? ¿Le gusta?
2. ¿Cuál fue el primer trabajo que consiguió después de graduarse?
3. ¿Alguna vez tuvo un trabajo muy raro?
4. ¿En qué pensaba que trabajaría al crecer?
5. Si pudiere elegir un trabajo ahora, ¿qué haría?

Citas

1. ¿Adónde por aquí sale Ud. para una cita romántica?
2. ¿Qué haría?
3. ¿Se acuerda de una cita que no fuera bien? ¿Qué pasó?
4. ¿Había algún tipo con quien sus padres no lo/la dejaran salir?

Conducción

1. ¿Maneja Ud. un auto?
2. ¿Es difícil llegar adonde quiera sin tener carro? Si necesitara un carro en una emergencia, ¿a quién se lo pediría?
3. ¿Alguna vez toma el autobús?
4. ¿Cómo son los conductores de aquí?

Tradiciones familiares

1. ¿Qué tradiciones familiares tiene/tenía en su familia?
2. ¿Celebraban la Navidad de niño/niña?
3. ¿Cuál era su regalo navideño favorito? ¿Por qué?
4. ¿Hay o había una comida típica navideña?
5. ¿Qué hacían/hacen en el año nuevo?
6. ¿Cuál es su fiesta favorita? ¿Por qué? ¿Qué hacen?
7. ¿Cómo compara las tradiciones entre los hispanos y los anglosajones?
8. ¿Es su familia muy religiosa?
9. ¿Es la religión importante para la comunidad?
10. ¿Y la política? ¿Le gusta discutir política?

Pasatiempos

1. ¿Le gusta mirar la tele? ¿Qué mira?
2. ¿Le gusta leer? ¿Qué tipo de lectura?
3. ¿Le gusta ir al cine? ¿Qué tipo de película?
4. ¿Practica deporte? ¿Cuál?
5. ¿Se reúne con amigos frecuentemente?
6. ¿Le gusta salir o prefiere quedarse en la casa?

Sueños

1. ¿Alguna vez tuvo un sueño que le asustara mucho?
2. ¿Los sueños significan algo?

Peligro

1. ¿Alguna vez ha tenido mucho miedo de algo?
2. ¿Cuándo fue? ¿Qué pasó?
3. ¿Alguna vez ha estado en una situación en la que estuviera en grave peligro, en la que se dijera, "ahora mismo me voy a morir"? ¿Qué pasó?
4. ¿Alguna vez pasó algo cuando Ud. crecía que no pudiera explicar?

Vida

1. ¿Cuál fue el momento más feliz de su vida?
2. ¿Quién fue la persona más importante en su vida? ¿Me puede contar más acerca de él/ella?
3. ¿Quién ha tenido más influencia en su vida?
4. ¿En qué resultó diferente su vida de lo que había imaginado?

Lengua

1. ¿Qué lenguas se hablan en este vecindario?
2. Cuando conoce a una persona latina por primera vez, ¿cómo sabe si hablar en inglés o español?
3. ¿Diría Ud. que es bilingüe?
4. ¿Qué requiere ser bilingüe? ¿Es importante ser bilingüe?
5. ¿Hay palabras o expresiones que usa solamente en inglés? ¿español?
6. ¿Cree que todos los hablantes del español en Florida / New Jersey hablan de la misma manera?
7. ¿Cómo es el español de Florida / New Jersey en comparación con el español en otros lugares de los Estados Unidos?
8. ¿Cree Ud. que hay algún lugar donde se habla mejor el español? ¿Por qué?
9. Si tuviera que nombrar alguien que hable el mejor español, ¿a quién nombraría?
10. En la escuela, ¿alguna vez le corrigieron sus maestros su manera de hablar?

APPENDIX C: LANGUAGE BACKGROUND QUESTIONNAIRE

Start of Block: Demographics

- o Participant number __________
- o Age __________
- o Gender __________

Where were you born?

- o U.S.
- o Outside the U.S.

If you were born outside the U.S.:

- o Where were you born? __________
- o What age did you arrive to the U.S.? __________
- o What city, state did you come to? __________

Where was your mother born?

- o U.S.
- o Colombia (What city/region?) __________
- o Other __________

Where was your father born?

- o U.S.
- o Colombia (What city/region?) __________
- o Other __________

Where were your maternal grandparents born?

- o U.S.
- o Colombia (What city/region?) __________
- o Other __________

Where were your paternal grandparents born?

- o U.S.
- o Colombia (What city/region?) __________
- o Other __________

Current residence:

- o Where do you currently live? (city, state) __________
- o How long have you lived there? __________

In your current community, what language(s) do you hear the most?

- ○ English
- ○ Spanish
- ○ Both English and Spanish equally
- ○ Other __________

Do you have siblings?

- ○ No
- ○ Yes (how many?) __________
- ○ My birth order is: (oldest, youngest, etc) __________

What language do you use with your siblings?

- ○ English
- ○ Spanish
- ○ Both English and Spanish equally
- ○ Other __________

What is the highest level of school you have completed or the highest degree you have received?

- o Less than high school degree
- o High school graduate (high school diploma or equivalent including GED)
- o Some college but no degree
- o Associate degree in college (2-year)
- o Bachelor's degree in college (4-year)
- o Master's degree
- o Doctoral degree
- o Professional degree (JD, MD)

Was any of your education mainly in Spanish?

- o No
- o Yes (please list education in Spanish) __________

Which of the following educational practices have you participated in? (more than one may be selected)

- ESL (English as a second language) classes
- Spanish classes (for native speakers)
- Spanish classes (for non-native speakers)
- Bilingual education
- English-only education
- Spanish-only education
- Other (please explain) __________

What is your current occupation?__________

Which description(s) do you identify with: (more than one may be selected)

- Colombian
- Colombian-American
- American
- Latinx/o/a
- Hispanic
- Spanish
- Chicanx/o/a
- Other (please specify) __________

End of Block: Demographics

Start of Block: Language Use

From age 0-5 in which language did you speak to the following people?

	Always Spanish	Mostly Spanish	Both languages equally	Mostly English	Always English	N/A
Maternal Grandparents	○	○	○	○	○	○
Paternal Grandparents	○	○	○	○	○	○
Mother	○	○	○	○	○	○
Father	○	○	○	○	○	○
Siblings	○	○	○	○	○	○
Cousins	○	○	○	○	○	○
Friends	○	○	○	○	○	○
Other family members	○	○	○	○	○	○
Local community members	○	○	○	○	○	○

In elementary/middle school in which language did you speak to the following people?

	Always Spanish	Mostly Spanish	Both languages equally	Mostly English	Always English	N/A
Maternal Grandparents	○	○	○	○	○	○
Paternal Grandparents	○	○	○	○	○	○
Mother	○	○	○	○	○	○
Father	○	○	○	○	○	○
Siblings	○	○	○	○	○	○
Cousins	○	○	○	○	○	○
Friends	○	○	○	○	○	○
Other family members	○	○	○	○	○	○
Local community members	○	○	○	○	○	○
Teachers / School staff	○	○	○	○	○	○

In high school in which language did you speak to the following people?

	Always Spanish	Mostly Spanish	Both languages equally	Mostly English	Always English	N/A
Maternal Grandparents	○	○	○	○	○	○
Paternal Grandparents	○	○	○	○	○	○
Mother	○	○	○	○	○	○
Father	○	○	○	○	○	○
Siblings	○	○	○	○	○	○
Cousins	○	○	○	○	○	○
Other family members	○	○	○	○	○	○
Friends	○	○	○	○	○	○
Local community members	○	○	○	○	○	○
Teachers / School staff	○	○	○	○	○	○

In which language do you currently speak to the following people?

	Always Spanish	Mostly Spanish	Both languages equally	Mostly English	Always English	N/A
Maternal Grandparents	○	○	○	○	○	○
Paternal Grandparents	○	○	○	○	○	○
Mother	○	○	○	○	○	○
Father	○	○	○	○	○	○
Siblings	○	○	○	○	○	○
Cousins	○	○	○	○	○	○
Other family members	○	○	○	○	○	○
Friends	○	○	○	○	○	○
Coworkers	○	○	○	○	○	○
Local community members	○	○	○	○	○	○

Who are the 5 people you use Spanish with the most?
(write relationship: cousin, grandmother, etc)

- ○ 1 ___________
- ○ 2 ___________
- ○ 3 ___________
- ○ 4 ___________
- ○ 5 ___________

In which language do you currently use for the following activities?

	Always Spanish	Mostly Spanish	Both languages equally	Mostly English	Always English	N/A
Watching TV	o	o	o	o	o	o
Listening to music	o	o	o	o	o	o
Listening to the radio	o	o	o	o	o	o
News (reading, watching)	o	o	o	o	o	o
Reading	o	o	o	o	o	o
Church/Community activities	o	o	o	o	o	o
Shopping in my neighborhood/local community	o	o	o	o	o	o
Whatsapp, texting, email	o	o	o	o	o	o
Social media (Facebook, Twitter, Instagram, etc)	o	o	o	o	o	o

End of Block: Language Use

Start of Block: Language proficiency

Indicate how well you speak, understand, read, and write in English and Spanish

	Extremely well	Very well	Moderately well	Slightly well	Not well at all
How well do you speak English?	o	o	o	o	o
How well do you speak Spanish	o	o	o	o	o
How well do you understand English?	o	o	o	o	o
How well do you understand Spanish?	o	o	o	o	o
How well do you read English?	o	o	o	o	o
How well do you read Spanish?	o	o	o	o	o
How well do you write English?	o	o	o	o	o
How well do you write Spanish?	o	o	o	o	o

How often do you interact with English and Spanish?

	Daily	Multiple times a week	Monthly	Yearly	Only in certain situations	Never
I hear Spanish	o	o	o	o	o	o
I hear English	o	o	o	o	o	o
I speak Spanish	o	o	o	o	o	o
I speak English	o	o	o	o	o	o
I read in Spanish	o	o	o	o	o	o
I read in English	o	o	o	o	o	o
I write in Spanish	o	o	o	o	o	o
I write in English	o	o	o	o	o	o

End of Block: Language proficiency

Start of Block: Attitudes

Where is the best Spanish spoken?__________

Someone who is bilingual can:

- ○ Use English and Spanish equally well
- ○ Speak at least some of both English and Spanish
- ○ Understand at least some of both English and Spanish
- ○ Other __________

Please read the following statements and say whether you agree or disagree with the statements. There are no right or wrong answers.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
It is important to be able to speak English and Spanish	○	○	○	○	○	○	○
Children get confused when learning English and Spanish	○	○	○	○	○	○	○
Children should learn to read in both English and Spanish	○	○	○	○	○	○	○
Schools should teach both English and Spanish	○	○	○	○	○	○	○
Speaking both Spanish and English helps to get a job	○	○	○	○	○	○	○
Being able to write in Spanish is important	○	○	○	○	○	○	○
Speaking in two languages is not difficult	○	○	○	○	○	○	○
Both Spanish and English are important where I live	○	○	○	○	○	○	○
If I have children, I would want them to speak both Spanish and English	○	○	○	○	○	○	○

Please read the following statements and say whether you agree or disagree with the statements. There are no right or wrong answers.

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I like hearing Spanish	o	o	o	o	o	o	o
I like speaking Spanish	o	o	o	o	o	o	o
I feel like myself when I speak Spanish	o	o	o	o	o	o	o
People should only speak English or Spanish without mixing them	o	o	o	o	o	o	o
Spanish is essential to take part fully in my community	o	o	o	o	o	o	o
Spanish is essential to take part fully in my family events	o	o	o	o	o	o	o
Spanish should be maintained for future generations	o	o	o	o	o	o	o
It is common for a child's Spanish to sound different from their parents	o	o	o	o	o	o	o
Spanish should only be maintained if it is proper Spanish	o	o	o	o	o	o	o
My Spanish sounds nativelike	o	o	o	o	o	o	o
My Spanish sounds Colombian	o	o	o	o	o	o	o

End of Block: Attitudes

APPENDIX D: INDIVIDUAL DISTRIBUTION OF MANNER CATEGORY BY TASK

Participant	Task	PA		TA		Stop	
		n	%	n	%	n	%
Dalia	Reading	83	58.04%	37	25.87%	23	16.08%
	Conversation	115	72.78%	36	22.78%	7	4.43%
Andrea	Reading	90	63.38%	15	10.56%	37	26.06%
	Conversation	74	86.05%	9	10.47%	3	3.49%
Lollipop	Reading	65	45.45%	62	43.36%	16	11.19%
	Conversation	147	77.78%	36	19.05%	6	3.17%
MommaKat	Reading	60	41.67%	74	51.39%	10	6.94%
	Conversation	63	67.02%	26	27.66%	5	5.32%
Lola	Reading	37	25.69%	89	61.81%	18	12.50%
	Conversation	1	33.33%	2	66.67%	0	0.00%
María	Reading	16	11.68%	67	48.91%	54	39.42%
	Conversation	170	82.13%	34	16.43%	3	1.45%
Sergio	Reading	86	60.56%	27	19.01%	29	20.42%
	Conversation	84	93.33%	6	6.67%	0	0.00%
Carmen	Reading	37	25.69%	57	39.58%	50	34.72%
	Conversation	145	83.33%	23	13.22%	6	3.45%
Liliana	Reading	1	0.71%	49	34.75%	91	64.54%
	Conversation	0	0.00%	1	50.00%	1	50.00%
Marby	Reading	13	9.22%	39	27.66%	89	63.12%
	Conversation	135	79.88%	17	10.06%	17	10.06%
Janine	Reading	10	6.99%	67	46.85%	66	46.15%
	Conversation	196	73.68%	52	19.55%	18	6.77%
Mariela	Reading	54	37.76%	53	37.06%	36	25.17%
	Conversation	76	85.39%	11	12.36%	2	2.25%
Esperanza	Reading	78	54.17%	57	39.58%	9	6.25%
	Conversation	32	78.05%	9	21.95%	0	0.00%
Katrina	Reading	47	32.64%	62	43.06%	35	24.31%
	Conversation	61	75.31%	15	18.52%	5	6.17%
Maximos	Reading	14	9.72%	26	18.06%	104	72.22%
	Conversation	3	15.00%	5	25.00%	12	60.00%
Victor	Reading	55	38.73%	48	33.80%	39	27.46%
	Conversation	53	91.38%	3	5.17%	2	3.45%

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