Cross-Language Phonological Influence in Spanish-English Code-Switching

by

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ABSTRACT

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Thesis directed by Associate Professor Rebecca Scarborough

While it is known that bilinguals have cross-language interactions between phonological processes and that code-switching can strengthen within-speaker cross-language phonetic convergence, few studies have examined whether code-switching can strengthen cross-language phonological interactions. This study explores the effects of code-switching on the cross-language transfer of phonological processes between a bilingual's two phonological systems. I investigate two main questions: 1) Can a bilingual speaker cross-linguistically transfer phonological processes (promotion) or the lack of particular processes (inhibition) in a code-switching context?; and 2) Do code switches affect the degree and/or frequency of these cross-language influences? I examine the English tapping process (/t/ → [ɾ]) and the Spanish spirantization process (/d/ → [ð]) in both languages in spontaneous code-switched speech. Data was collected from the Miami Corpus (Bangor University's Centre for Research on Bilingualism in Theory and Practice).

Results indicate that code-switching can indeed affect bilinguals' cross-language transfers of phonological processes. This occurs through process promotion, wherein a process of one language is transferred into the other language, and process inhibition, wherein the *lack* of a particular process in one language is transferred into the other. These cross-language transfers exert influence as partial promotions or inhibitions, realized as phonetically gradient effects (e.g., Spanish /t/ realized as a more tap-like /t/), and occasionally as more complete promotions, realized as a categorically distinct allophone (e.g., Spanish /t/ realized as [ɾ]). These results

indicate that code-switching can strengthen the interactions between a bilingual’s two phonological systems.

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1. INTRODUCTION

Bilinguals have distinct phonological systems for each language, which interact with each other and are dependent on context. Speech production in a bilingual's two languages can undergo low-level phonetic convergence, and phonological processes of one language can influence the other language. Language dominance, sequence of bilingualism (L1 versus L2), and speech context significantly affect cross-language influences. Code-switching contexts are an example of this, and literature on this provides ample evidence that code-switching contexts promote cross-language low-level phonetic convergence for features such as voice onset time and vowel quality. However, literature on cross-language phonological interactions in code-switching is quite limited. This study aims to determine whether code-switching contexts can affect cross-language influences of phonological processes. This study will provide a better understanding of the relationship between bilinguals' two phonologies, the relationship between code-switching contexts and cross-language phonological influence, and the nature of cross-language influence for different phonological processes.

1.1 PHONOLOGY OF BILINGUALS

Bilinguals develop connections between the phonetic categories of one of their languages and the closest phonetic categories of their other language. These connections between the languages are malleable, meaning that a context favoring one language or activating both languages can strengthen or inhibit these connections, respectively (Simonet, 2016). For example, Sancier and Fowler (1997) found that a Portuguese–English bilingual produced English-like VOTs in Portuguese in America and Portuguese-like VOTs in English in Brazil, presumably due to the language primarily spoken by the speaker in each of those environments. Simonet (2014) found that in a Catalan-Spanish bilingual context, two Catalan vowels became acoustically more similar in vowel quality to a particular Spanish vowel than they were in a unilingual session. Particularly relevant to the current study, Simonet and Amengual (2020) found that in a Catalan-Spanish bilingual setting, Catalan's phonological process of unstressed /a/ reduction to [ə], which does not occur in Spanish, was influenced by the lack of this process in Spanish, such that Catalan unstressed /a/ converged slightly toward Spanish unstressed /a/ in this context. This demonstrates that one language's lack of a phonological process can interfere with the application of that process in the other language.

Other studies show effects of speakers' sequence of bilingualism (L1 and L2). Flege (1987) found that French-English bilinguals' voiceless stop VOTs in their native language and second language converged; their VOTs were therefore in between the monolingual controls for the target and source languages. Simon (2010) found that native Dutch (L1) speakers learning English (L2) applied the Dutch phonological processes of word-final devoicing and cross-word voicing assimilation into English conversational speech, indicating that for late bilinguals, phonological processes can exert cross-language influence on phonetic realizations. Similarly, speakers often apply the phonotactics of their L1 to their L2 – for example, native Spanish speakers often prevent /s/ + consonant onsets (which are phonologically illegal in Spanish) in L2 English by inserting an /e/ at the beginning to split the consonant cluster onset by turning the /s/ into a coda, resulting in the production of words like *eschool* or *estudy* (Freeman et al. 2016).

1.2 PHONETICS OF CODE-SWITCHING

As previously noted, context can strengthen and inhibit connections between a bilingual's two languages' phonetic categories. One such context is code-switching, which is "the usage by bilinguals (or multilinguals) of at least two languages during the same interaction" (Olson, 2016, pp. 453-454). Studies have investigated cross-language phonetic and phonological influences in code-switching contexts, with the majority of these focusing on phonetic interactions and only a small number focusing on phonological interactions.

Voice onset time (VOT) was the first and most frequently studied measure of cross-language phonetic influence in code-switching, with most of these studies examining Spanish-English code-switching. These studies have examined both spontaneous and scripted speech and have investigated the roles of various factors such as language dominance, sequence of bilingualism, and a token's direction in relation to a code switch. The results of these studies vary, with many finding asymmetric cross-language influences, some finding bidirectional convergence (Bullock & Toribio, 2009), some finding that both English and Spanish VOT were shorter at code-switching points than in monolingual speech (Piccinini & Arvaniti, 2015; Bullock et al., 2006), and others finding no evidence of cross-language influence in either language (Grosjean & Miller, 1994).

Numerous studies have concluded that each language's inherent range of VOT values plays a role in the patterns of cross-language phonetic influence. In Spanish-English code-switching, English VOT ranges have been found to converge toward Spanish VOT ranges. Spanish short lag voiceless stops have a VOT range of approximately 0-30 ms, while English long lag voiceless stops have a wider VOT range or approximately 30-120 ms. The larger VOT range for English voiceless stops allows them to get shorter (become more Spanish-like) without becoming categorically (phonologically) Spanish, while the smaller VOT range for Spanish voiceless stops means that getting longer (to become more English-like) would instead actually make them categorically English. Thus, speakers allow English VOT to be cross-linguistically influenced but prevent Spanish VOT from being influenced (Bullock & Toribio, 2009; Deuchar, 2011, Balukas & Koops, 2015; Antoniou et al., 2011).

Studies on VOT in Spanish-English code-switching have also looked at the role of various factors on the patterns of cross-language phonetic influence in code-switching. The directionality between the base/matrix language and the embedded language has not been shown to affect the patterns of cross-language phonetic influence (Grosjean & Miller, 1994; Bullock & Toribio, 2009). However, language dominance has been found to asymmetrically affect cross-language phonetic influence in code-switching such that a speaker's dominant language is susceptible to the influence of the non-dominant language (Antoniou et al., 2011; Olson, 2013). Additionally, varying interactions between L1 and L2 have been found, with one study finding L1→L2, L2→L1, and L1↔L2 influences, another finding that L1 predominantly influences L2 (with L2 being the dominant language in that case), and another finding that L2 predominantly influences L1 (with L1 being the dominant language). These studies show the importance of analyzing the interaction of the factors of L1, L2, and language dominance (Bullock & Toribio, 2009; Antoniou et al., 2011; Olson, 2013).

Other factors have been considered as well. Studies have seen various effects of direction, but both anticipatory (before the code switch) and carryover (after the switch) cross-language influences have been found to occur, both separately and concurrently (Bullock et al., 2006; Bullock & Toribio, 2009; Piccinini & Arvaniti, 2015; Piccinini, 2016). On the syntactic level, no significant difference was found between the influence on inter-phrasal and intra-phrasal code switches, which are "syntactically ill-formed" (Toribio et al., 2005, p. 296). Position within a word (word-initial versus word-final) did not have an effect on cross-language influences on /l/ velarization rates (Piccinini, 2016). Lastly, distance from a code switch (measured in time or words) has been found to correlate with influence on VOT in English, but not in Spanish (Balukas & Koops, 2015; Piccinini & Arvaniti, 2015).

Studies have also investigated other forms of cross-language phonetic influences. Elias, McKinnon, and Milla-Muñoz (2017) found that Spanish-English code-switching affected vowel duration and quality in heritage speaker Spanish such that code-switched vowels were more centralized than vowels in monolingual Spanish contexts and unstressed vowels were more centralized and shorter than stressed vowels, due to the influence of English's reduction patterns. Additionally, Piccinini (2016) found that the duration and formant values of word segments (/laɪ/ from the word /laɪk/) in code-switching contexts were in between the English and Spanish monolingual values. It is important to note that for both VOT and vowel quality, all results show that code-switching can only effect low-level phonetic influences and cannot cause a language to shift to the phonological categories of the other language (Balukas & Koops, 2015; Bullock, 2009; Bullock & Toribio, 2009; Olson, 2013; Piccini & Arvaniti, 2015).

1.3 PHONOLOGY OF CODE-SWITCHING

A few studies have found cross-language influence involving phonological processes in code-switching. For example, Olson (2019) found that phonological processes can occur across code-switch points, with the context in one language and the effect in the other. Stefanich et al. (2019) found that while intra-word code switches can occur, wherein a word contains morphemes from two languages, bilinguals did not seem to be able to easily use elements from both languages' phonological systems within the same word, even when a root came from one language and an affix from the other. Bilinguals instead use one phonological system for the whole code-switched word – specifically, that of the language of the affix(es). Thus, one language's phonology is cross-linguistically transferring to a morpheme from another language in a code-switched word. Henriksen et al. (2021) found that a lack of intervocalic voiced stop spirantization in L1 Afrikaans inhibited the application of this process in L2 Spanish in code-switching contexts, resulting in lessened lenition. Lastly, Piccinini (2016) found that /l/ velarization rates in English and Spanish converged in code-switching contexts.

Conversely, a few studies have found a lack of cross-language phonological process influence in code-switching. Brown (2015) found that the Spanish-English code-switching context had no impact on word-initial /d/ reduction (spirantization or deletion) rate in Spanish in spontaneous speech of New Mexico Spanish-English bilinguals. Piccinini (2016) found that code-switching contexts do not affect the frequency of lenition in word-initial voiced stops in either Spanish or English (i.e., English did not inhibit the frequency of voiced stop lenition in Spanish, and Spanish did not cause an increased frequency of voiced stop lenition in English) when analyzed categorically (i.e., coded as either stop or fricative/approximant) from scripted speech of heritage Spanish speakers. The direction of the token in relation to the code switch (anticipatory/pre-switch versus perseverative/carryover/post-switch) did not have any effect.

1.4 CURRENT STUDY

Past studies have shown a number of cross-language influences, but they have not incorporated all possible relevant factors. Furthermore, many of the factors that have been incorporated have only been investigated in analyses of phonetic influence, not analyses of phonological influence. Moreover, past studies on phonological cross-language influence in code-switching have only examined the influence of/on a process of one language in a code-switching context; none has done a bidirectional analysis looking simultaneously at a process from each language. Also, these studies look almost solely at spirantization in stops, with almost no attention to other phonological processes, such as tapping. Lastly, as will be further discussed later, no other study has looked at both gradient and categorical influences for the same phonological process(es).

This study aims to fill these research gaps and expand on research on cross-language phonological influence in code-switching. The area of cross-language phonological influence has not been studied enough, especially with respect to code-switching contexts and phonological processes (as opposed to phonological categories). Although the existing studies in this intersection have not found much evidence of phonological processes influencing the other language in code-switching, and phonetic influences do not reach the extent of changing phonological categories, the evidence of cross-language phonetic influence in code-switching and the evidence of cross-language influence of phonological processes in bilingual speech contexts, along with some evidence of phonological process interaction in code-switching contexts, suggest the potential for cross-language influences of phonological processes in code-switching contexts. The results of this study will provide insight on the presence and nature of cross-language influences of phonological processes in code-switching, including the unexplored tapping process. This will then provide insight on the interactions between a bilingual's two phonological systems.

RESEARCH QUESTIONS

Fundamentally, this research asks whether phonological processes have cross-linguistic influences in code-switching contexts – specifically, whether phonological processes are promoted in one language by a process that would only occur in the other language and whether phonological processes in one language are inhibited by the lack of that process in the other language. It also asks whether a code switch affects the degree and/or frequency of cross-linguistic influences. To evaluate these two basic research questions, I investigate the following questions:

1. Does the **distance** from the code switch determine the degree (of gradient influence)/likelihood (of categorical influence) of the cross-language influence?
2. Does a token's **direction** from the code switch affect its degree/likelihood of influence (i.e., are tokens more likely to be influenced before or after a code switch)?
3. Does the **sentence level** of the code switch in which a token occurs affect its degree/likelihood of influence (i.e., are tokens in intrasentential code switches or tokens in intersentential code switches more likely to be influenced)?
4. Are phonological processes **more likely** to be **promoted** by the other language than to be **inhibited** by the other language?
5. Does the **dominant language** in a conversation affect the patterns of influence?

To investigate these questions, I will analyze intervocalic cases of the /d/ → [ð] spirantization process of Spanish and the /t/ → [ɾ] tapping process of English in Spanish-English code-switching contexts in spontaneous speech. In the /d/ spirantization process of Spanish, the voiced stop /d/ undergoes lenition to become the voiced fricative [ð] in various contexts, including intervocalic contexts. In the /t/ tapping process of English, the voiceless stop /t/ is produced as the voiced [ɾ] in intervocalic contexts in which the following vowel is unstressed (if it occurs within the same word; i.e., across word boundaries, the vowel stress is irrelevant).

HYPOTHESES

I hypothesize that a process from one language will be fully or partially realized in the other language across a code switch. Specifically,

1. The English /t/ → [ɾ] tapping process will influence Spanish /t/ realizations near the code switch by causing them to become more tap-like. Thus, Spanish /t/s will be shorter and louder in code-switching contexts.

2. The Spanish /d/ → [ð] spirantization process will influence English /d/ realizations near the code switch by causing them to become more eth-like. Thus, English /d/s will be louder in code-switching contexts.

I hypothesize that a process from one language will be inhibited due to the lack of that process in the other language. Specifically,

3. The degree/likelihood of English /t/ tapping will decrease near the code switch, due to the influence of Spanish's lack of /t/ tapping. Thus, English /t/s will be longer and quieter in code-switching contexts.
4. The degree/likelihood of Spanish /d/ spirantization will decrease near the code switch, due to the influence of English's lack of /d/ spirantization. Thus, Spanish /d/s will be quieter in code-switching contexts.

I also hypothesize that distance from a code switch will affect the cross-language influences. Specifically,

5. The cross-language influences will strengthen as distance from a code switch decreases (i.e., closer to a code switch).

These hypotheses are mapped out below in Figures 1 and 2, which show both possible orders of the languages in the code switches. The hypotheses are labelled within the diagrams as H1-H4. Promoting effects are shown in the bottom half of each diagram, while inhibiting effects are shown in the top half. The diagrams demonstrate the patterns of speech production over time. The diagonal lines represent the degree (of gradient influence)/likelihood (of categorical influence) of a cross-language influence in a code-switching context, as based on distance.

Figure 1: Hypotheses in Spanish → English Code Switch

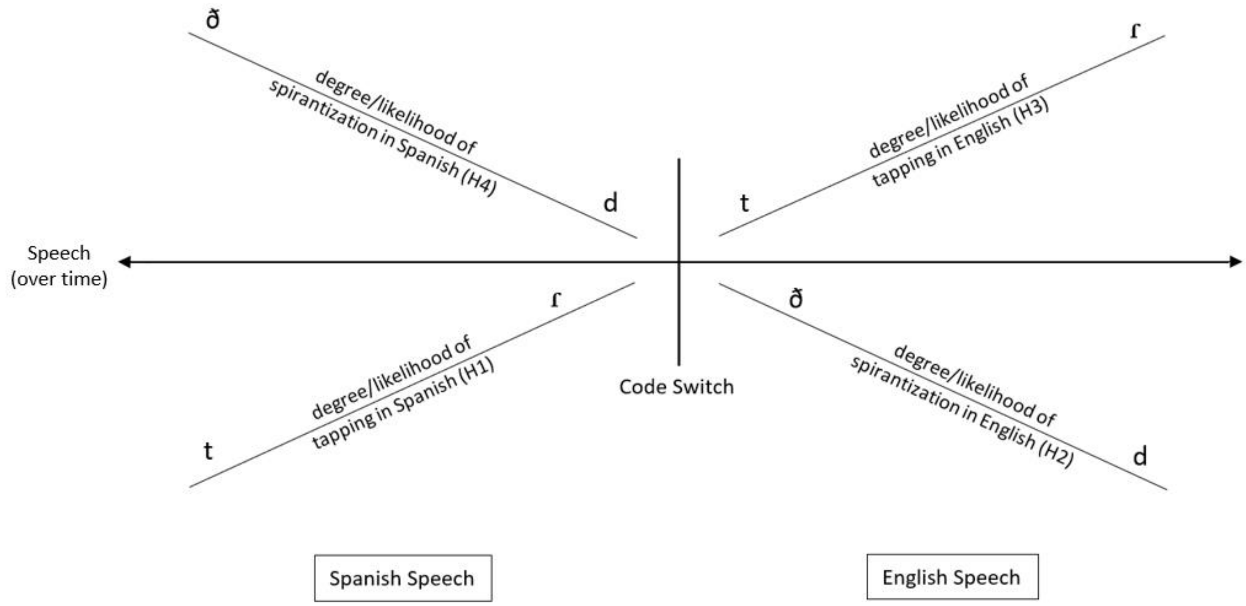
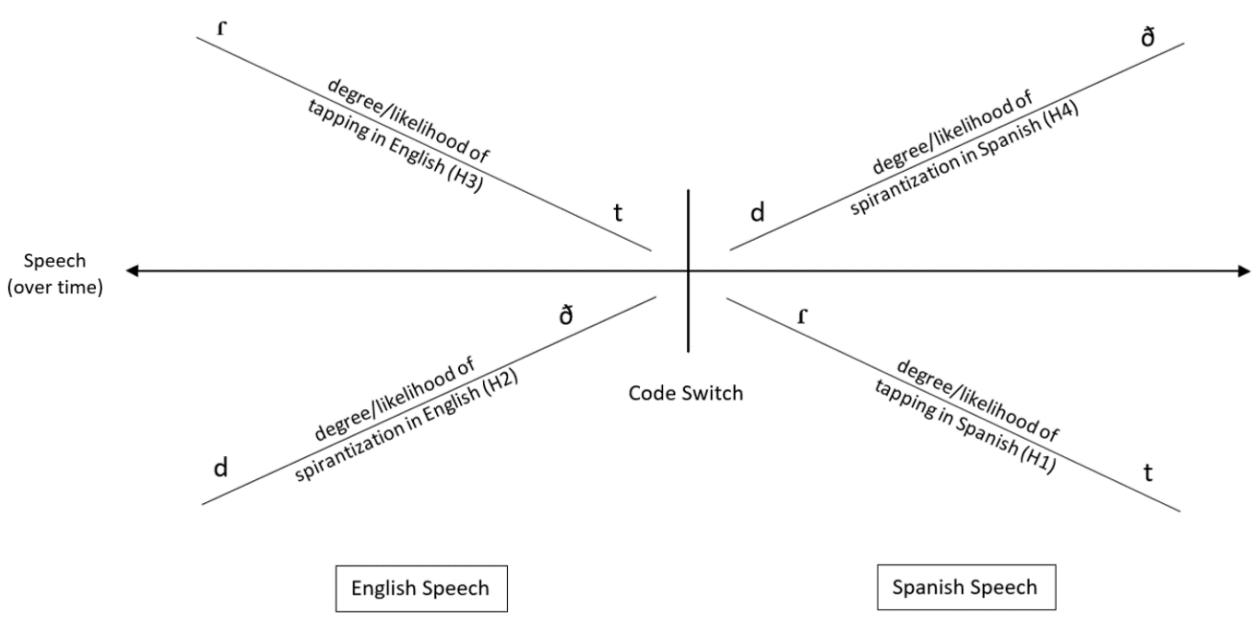


Figure 2: Hypotheses in English → Spanish Code Switch



2. METHODOLOGY

As previously mentioned, the current study focuses on the phonological processes of intervocalic /d/ spirantization in Spanish and /t/ tapping in English. Each process occurs in one of the languages but not the other. Further, these processes were chosen for their resulting allophones' phonemic contrast in the opposite language. [ð] is allophonic in Spanish but a contrastive phoneme in English, while [ɾ] is allophonic in English but a contrastive phoneme in Spanish. This was done to allow us to investigate the role of the systems of phonemic contrast within the bigger picture of cross-language phonological process influences in code-switching and of the interactions of bilinguals' phonological systems more generally.

2.1 GRADIENT INFLUENCE VERSUS CATEGORICAL INFLUENCE

The duration and amplitude measurements of each token were measured gradiently to assess the degree of spirantization or tapping, rather than categorically labeling each token as a particular allophone. This was done to determine whether the phonological processes had any low-level phonetic effects (i.e., gradient influence), even if not being fully realized in the other language.

Distance from the code switch was also measured gradiently (as the number of syllables from the code switch). Distance from the code switch was analyzed for potential effects on the degree of gradient influence and/or likelihood of categorical influence.

In addition, individual tokens that appeared to be fully realized as the code switch-motivated target allophone (i.e., the four inner allophones in the hypothesis diagrams; e.g., expected [t] realized as [ɾ] in Spanish, expected [ɾ] realized as [t] in English, etc.) were marked as having a categorical influence from the opposite language. Categorical influence tokens were labelled for two reasons. First, examination of the presence and frequency of categorical tokens can offer insight into the nature of cross-language phonetic/phonological transfer, indicating whether only low-level phonetic influences can occur, as nearly all the literature suggests, or a full transfer of a phonological process can occur. Second, determining the frequency of categorical tokens can inform our analysis of gradient effects. It would be important to determine whether any gradient effects are due to a moderate number of tokens with categorical influence (i.e., strong influence in a sufficient number of tokens) or many tokens with phonetically gradient/low-level influence (i.e., sufficient influence in a large number of tokens).

Tokens that appeared (visually and auditorily) to be halfway between the expected allophone and the code switch-motivated target allophone were marked as having a halfway influence. The term *halfway* refers to the fact that although there is not a categorical influence, the gradient effect is strong enough that the phonological process is applied halfway; this term is also an appropriate way to think of the type of influence of these tokens, as it is essentially halfway between a gradient influence and a categorical influence.

These different types of influence are categorized according to their different allophonic realizations. However, the same overall process of influence is occurring in all three types. In all of these cases, a phonological process of lack of a particular process is being “transferred” into the other language. The process or lack thereof is then applied – resulting in the promotion or inhibition of a phonological process. These applications (i.e., promotions or inhibitions) are realized as influences on a token – either partially, which results in a gradient influence, or more completely, which results in a categorical influence. Thus, a categorical influence can be thought of as an extremely strong gradient influence. Again, though the same manner of application leads to both gradient and categorical influences, the difference is that the final realization of a gradient influence is still identifiable as the original, typical allophone, while the final realization of a categorical influence is identifiable as an entirely distinct allophone.

2.2 DATA COLLECTION

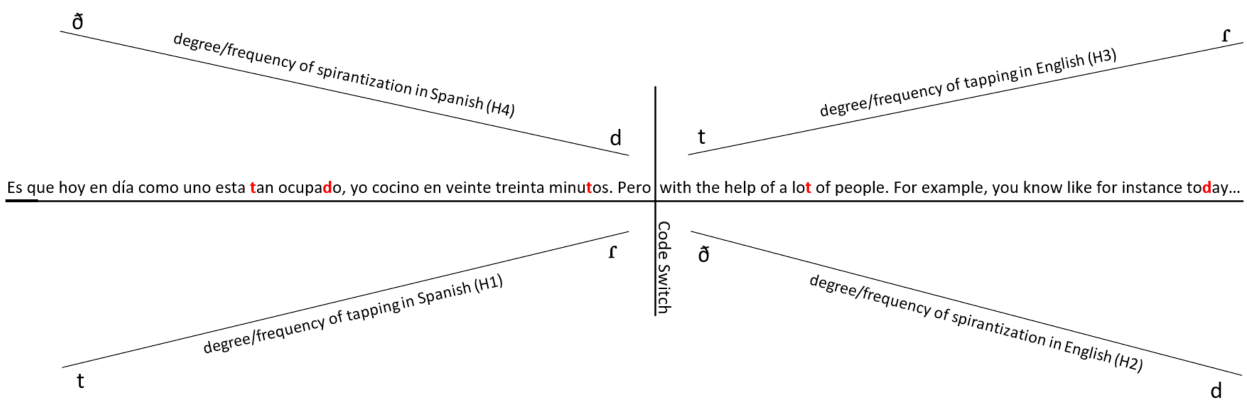
Data was collected from the Miami Corpus from Bangor University's Centre for Research on Bilingualism in Theory and Practice. Tokens were pulled from three dyadic, spontaneous, familiar conversations between Spanish-English bilinguals that presumably occurred in Miami. Only dyadic conversations were used due to the higher likelihood of a speaker's turn lasting long enough for a code switch and potentially more usable tokens to occur. Specific conversations were then selected for their sufficient number of turns containing code switches and the clarity of the audio files. All speakers in those conversations were included, with one exception. In one conversation, the name and lines of one of the two speakers were redacted in both the transcript and audio file. The five speakers were female Spanish-English bilinguals at the ages of 22, 29, 45, 48, and 60 years old. See Appendix A for transcripts of the conversations.

TOKENS COLLECTED AND CODE SWITCH CRITERIA

The conversation transcript was used to find instances of intervocalic /t/s and /d/s in turns containing a code switch. In Spanish, intervocalic /t/ would canonically be realized as [t], and intervocalic /d/ as [ð] or ∅. In English, intervocalic /t/ and /d/ followed by an unstressed vowel would canonically be realized as [ɾ], and intervocalic /d/ followed by a stressed vowel would be realized as [d].

In the current study, sounds labelled as "taps" include all intervocalic /t/s in the appropriate vowel stress context (typically, followed by an unstressed vowel), which would typically be realized as English [ɾ]s and Spanish [t]s. Sounds labelled as "spirants" include all intervocalic /d/s, which would typically be realized as Spanish [ð]s, English [d]s, and English [ɾ]s. Both allophones of English /d/ ([d] and [ɾ]) were included with "spirants" as the focus is determining whether the /d/ spirantization process of Spanish is being applied to the underlying representation, the way it would be in Spanish. As mentioned, intervocalic Spanish /d/s are sometimes realized as ∅; in the current study, these realizations were not included in analyses of Spanish spirants due to their inability to be measured in Praat. Figure 3 below shows an example of the tokens collected from a turn containing a code switch.

Figure 3: Example of Cross-Language Influences in Data



All tokens of "taps" and "spirants" in appropriate contexts were measured, in both intersentential and intrasentential code switches, with the following exceptions. Tokens considered unusable included proper nouns, loan words, tokens produced with creaky voice, tokens where both speakers' speech overlapped, tokens with too much background noise, and tokens that have a pause between themselves and a surrounding vowel, which occurs most often when the token is at the edge of a sentence.

Tokens that occurred in a single-word code-switch were collected (except single-word code switches of proper nouns and loanwords), but tokens in the matrix language surrounding a single-word code switch were not included. Single code-switched words presumably could be influenced by the surrounding matrix language, but the single code-switched words were presumed not enough to cause an influence on the production of the matrix language. Table 1 below provides the number of tokens collected for the main categories of language and process.

Table 1: Collected Tokens

	"Spirants"	"Taps"	**Grand Total**
English	66	71	137
Spanish	78*	49	127
Grand Total	144	120	264

**There were additionally 47 instances of intervocalic Spanish /d/s realized as Ø, which were not included in analyses.*

2.3 MEASUREMENTS

Measurements were performed using Praat and the audio files from the corpus. The duration and average amplitude of each token were measured. Channels for each speaker were examined separately.

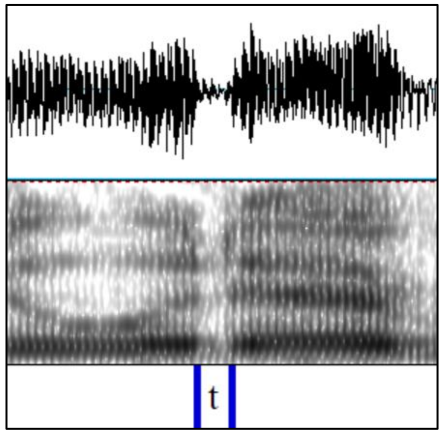
MEASUREMENT CRITERIA

The following criteria were used to identify the boundaries of the following allophones in Praat spectrograms and waveforms.

[ɾ]s

Tap boundaries were identified by the lower amplitude and sharp changes in formants, compared to the surrounding vowels. Generally, taps were identifiable by their voicing, moderate amplitude, and lack of a burst. However, some tap tokens were found to include a burst, in which case the other defining characteristics were relied upon. See Figure 4 for an illustration of a typical [ɾ] appearance in a spectrogram.

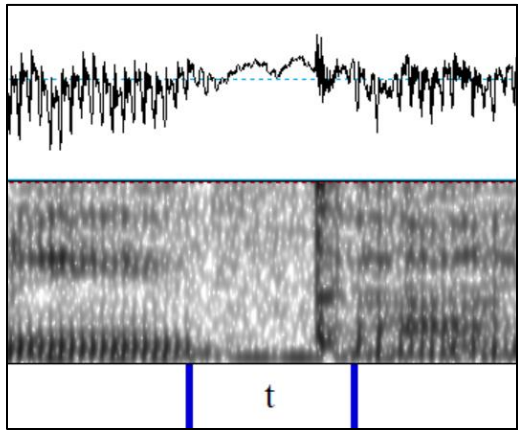
Figure 4: [ɾ] in Spectrogram



[t]s

Front [t] boundaries were identified by a significant decrease in amplitude from the preceding vowel, and the end boundaries were identified as the end of the burst, when present (or the aspiration, when present). Generally, [t]s were identifiable by their lack of amplitude and the presence of a closure without voicing followed by a burst. However, in some cases, background noise created amplitude during the closure, many tokens had some formant amplitude carryover from the preceding vowel, many tokens had voicing (possibly carryover from the preceding vowel), some tokens had long bursts (adopting frication more similar to that of spirants than usual), and some tokens did not have a burst. In cases where the [t] did not have a burst, the boundary was identified by the significant decrease in amplitude compared to the following vowel (similar to the identification of the front boundary). See Figure 5 for an illustration of a typical [t] appearance in a spectrogram.

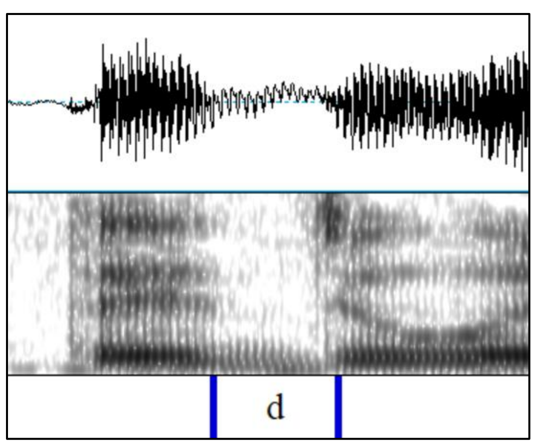
Figure 5: [t] in Spectrogram



[d]s

Similar to the identification of [t]s, the front boundaries of [d]s were identified by a significant decrease in amplitude in the preceding vowel, and the end boundaries were identified as the end of the burst, when present. [d]s were identified by their low amplitude and the presence of a closure with voicing followed by a burst. However, in some cases, a burst was not present, in which case the end boundary was identified in the same way [t] end boundaries were identified in tokens without bursts. See Figure 6 for an illustration of a typical [d] appearance in a spectrogram.

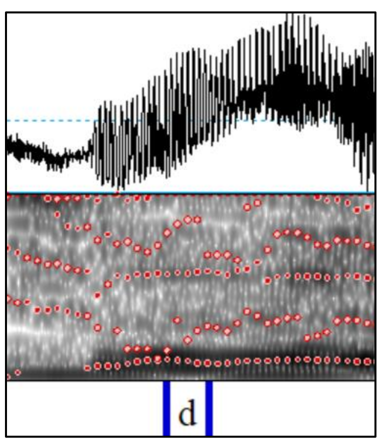
Figure 6: [d] in Spectrogram



[ð]s

[ð] boundaries ideally were characterized by a decrease in amplitude and changes in formant structure, compared to the surrounding vowels, as well as the presence of voicing and the lack of a burst. However, these cues were not always visible. In many cases, as is normal variation in Spanish, the [ð] was realized as an approximant, rather than a spirant, resulting in an amplitude and formant structure that nearly matched the surrounding vowels. In these cases, minor changes in the amplitude and/or formants were used to identify the boundaries. In some other cases, the underlying /d/ was deleted and realized as ∅, as determined by complete absence of the aforementioned cues and the lack of an audible [ð], in which case arbitrary boundaries were marked within the pair of surrounding vowels, and the token was labelled a deleted /d/. See Figure 7 for an illustration of a typical [ð] appearance in a spectrogram.

Figure 7: [ð] in Spectrogram



MEASUREMENT CORRELATES

The duration (in seconds) and amplitude (in dB) of each token were retrieved via script in Praat. The degree of tapping for [t] and [ɾ] tokens was measured in terms of both amplitude and duration, as [ɾ] is expected to be louder than [t] because it is voiced, while [t] is a voiceless stop.

[ɾ] should also be shorter because taps are inherently short. The degree of spirantization for [d] and [ð] tokens was measured in terms of amplitude, as [ð] is expected to have a higher amplitude because it is a fricative, whereas [d] is a voiced stop. Since the different speakers had varying overall loudness, amplitude measurements were normalized with standard scores.

2.4 VARIABLES

The three dependent measures – "tap" duration, "tap" amplitude, and "spirant" amplitude – were analyzed separately with respect to multiple predictor variables. In addition to the variables of language (English or Spanish), the variables of distance from the code switch, direction, sentence level, position, and the dominant language of a conversation were also incorporated into the analyses.

DISTANCE FROM THE CODE SWITCH

The distance of a token from the code switch was measured in the number of syllables. In cases where a token is both preceded and followed by a code switch within the same turn, the distance recorded was the distance between the token and the closer code switch. Word-initial and word-medial tokens were considered the onset of the following syllable. Word-final tokens were grouped with the word in which they occurred and considered the coda of the preceding syllable. Although deleted Spanish /d/ tokens were not collected, they were considered the onset or coda of the syllable in which they occurred, and that syllable was appropriately counted. One-word code switches from the other language were not considered code switches when counting syllables and were included with the matrix language in the syllable count. See Table 2 for examples of how tokens were syllabified.

Table 2: Syllabification Examples

		English	***Spanish***
Syllable Onset	**Word-Initial Token**	Go **t**o [ˈgoʊ **ɾ**ə] Buy **d**iscount [baɪ ˈ**d**ɪs kaʊnt]	Te **t**enía [te **t**e ˈni a] Que **d**icen [ke ˈ**ð**i sen]
	Word-Medial Token	Beau**t**iful [ˈbju **ɾ**ə fəl] Nowa**d**ays [naʊ wə ˈ**d**eɪz]	Boni**t**a [bo ˈni **t**a] Na**d**ie [ˈna **ð**ie]
Syllable Coda	**Word-Final Token**	Dele**t**e it [də ˈli**ɾ** ɪt] Ma**d** at [mæ**d** æt]	---

DIRECTION

The direction variable refers to the location of the token in reference to the code switch. As previously mentioned, direction is a factor that has often been included in past studies on cross-language influence in code-switching. "Anticipatory" tokens are those that occur before a code switch. "Perseverative" tokens are those that occur after a code switch. In instances where a token is both preceded and followed by a code switch within the same turn, the token was labelled relative to the closer code switch. In cases where the token is equidistant from both code switches, the token was labelled as "both"; however, only three tokens of "both" were found, so these were excluded from analyses due to the statistical unreliability of the small sample size.

SENTENCE LEVEL

The sentence level variable describes whether the token occurred near an intersentential code switch or an intrasentential code switch. "Intersentential" switches are code switches that occur between sentence boundaries (i.e., a sentence in one language followed by a sentence in the other language). "Intrasentential" switches are code switches that occur within a sentence (i.e., a sentence comprising multiple languages). Tokens that occurred near both an intersentential code switch and an intrasentential code switch were labelled "intrasentential," because past literature seems to suggest that intrasentential code switches are presumed more likely to support/motivate cross-language influence; thus, what is most significant is whether a token occurred near an intrasentential code switch.

POSITION

The position variable codes for the tokens' position within a word. The categories for this variable are "word-initial", "word-medial", and "word-final". Although position within a word is not inherently related to code-switching, unlike the other variables, it is included in the analysis due to the inherent variation in phonetic realizations and variability between different positions.

DOMINANT LANGUAGE OF A CONVERSATION

Language dominance has been examined in past studies on cross-language transfer in code-switching (and in bilingual contexts more generally), but in those cases this term referred to a speaker's dominant language. The current study, however, looks at which language was most prevalent in the conversation. In this case, two conversations were English-dominant, while one was balanced; therefore this study analyzes the percentage of English dominance of the conversation. The dominant language of each conversation was calculated based on the number of lines per language in each of the main conversations. Lines that contained both languages were grouped one of two ways: lines that had a vast majority of words in one language were coded as that language, while lines that had a relative balance between the number of words in either language were coded as "both". The number of lines for each category (Spanish, English, or both) was divided by the total number of lines in that conversation to generate a percentage. The resulting percentages for the three conversations were approximately 50%, approximately 70%, and approximately 90% English. As previously noted, one conversation had the lines of only one of its two speakers available; as a result, the percentages for that conversation were based only on the accessible speaker's lines.

2.5 STATISTICAL MODELING

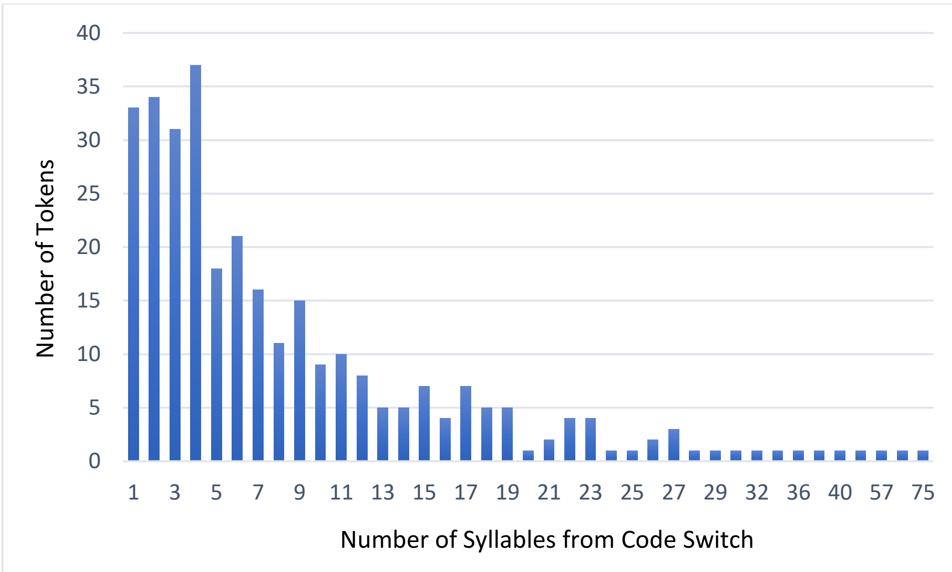
For each of the three dependent measures – "tap" duration, "tap" amplitude, and "spirant" amplitude – linear mixed effects models in with the fixed effects of language, distance, direction, position, and sentence level and a random effect of speaker were performed in R. Planned comparisons included four models that were run for each measurement type: a language by distance model, and then language by distance models that added direction, sentence level, and position, individually. Post-hoc analyses on dominant language were based on a language by dominance by distance model.

3. RESULTS

Patterns of gradient influence were found in all three measurement types – "tap" duration, "tap" amplitude, and "spirant" amplitude – and tokens with categorical influence or halfway influence were found for both tapping and spirantization. The following section presents the findings on gradient, categorical, and halfway influences.

For all of the data, as the number of syllables away from the code switch gets larger (i.e., farther away from the code switch/as distance from the switch increases), there is a greater number of tokens. See Figure 8 below for the distribution of tokens by syllable. This distribution occurred because tokens were selected based on their occurrence in a turn containing a code switch and most turns are relatively short. A smaller number of syllables per turn would mean an increased likelihood that the turn would have a relatively small number of tokens before or after the code switch, meaning more tokens should naturally occur relatively close to the code switch. It is especially unlikely that a speaker would have a turn long enough for there to be 25 or more syllables before or after the code switch in that turn. For that range, there is only a small number of sparsely distributed tokens (8 "spirants", 2 deleted Spanish /d/s, and 8 "taps"), making these tokens less statistically reliable. Accordingly, the tokens that occurred at 25 or more syllables away from the code switch were not included in analyses.

Figure 8: Number of Tokens per Syllable



3.1 GRADIENT INFLUENCE

Recall that *gradient influence* refers to influences on the degree of tapping or spirantization, as determined by duration and amplitude measures. As previously mentioned, each dependent measure (“tap” duration, “tap” amplitude, and “spirant” amplitude) was analyzed with respect to five variables: language (Spanish or English), distance from the code switch (number of syllables from the code switch), direction (anticipatory (before the code switch) or perseverative (after the code switch)), sentence level (intersentential or intrasentential), and position (word-initial, word-medial, or word-final).

TAPPING

Recall that I predict that tapping may increase in Spanish closer to the code switch (i.e., as distance from a code switch decreases), while tapping may decrease in English closer to a code switch. Table 3 below provides the number of "tap" tokens collected with respect to four of the five predictor variables. As a reminder, the term "taps" refers to all intervocalic /t/s in the appropriate vowel stress context in both English and Spanish, regardless of surface realizations. Typically, however, these would be realized as [ɾ] in English and as [t] in Spanish. For example, the tokens comprising this category include the /t/ in "go **t**o" and the /t/ in "a **t**ener".

Table 3: "Tap" Tokens Collected

	English	Spanish	Grand Total
Anticipatory	29	24	53
Intersentential	23	15	38
Initial	1	4	5
Medial	7	11	18
Final	15		15
Intrasentential	6	9	15
Initial		4	4
Medial	4	5	9
Final	2		2
Perseverative	41	24	65
Intersentential	21	18	39
Initial	3	7	10
Medial	2	11	13
Final	16		16
Intrasentential	20	6	26
Initial	6	3	9
Medial	7	3	10
Final	7		7
Grand Total	70*	48	118

*5 of the English /t/s, which would typically be realized as [ɾ] in this context, were realized as [t].

"Tap" Duration

Durations of potential taps (intervocalic English /t/s and Spanish /t/s), referred to as "taps", were examined to look for effects of code-switching on the phonetic/phonological realization of "taps". English intervocalic /t/ is expected to be shorter than Spanish intervocalic /t/ since it is canonically realized as [ɾ], and thus expected to be more tap-like, and taps are shorter than stops. As I predict that tapping may increase in Spanish in closer proximity to a code switch (gradiently more tap-like and/or more categorical [ɾ] tokens), I expect Spanish "taps" to be shorter closer to the code switch. As I predict that tapping may decrease in English closer to a code switch (gradiently less tap-like and/or fewer categorical [ɾ] tokens), I expect English "taps" to be longer closer to the code switch. Below are the findings on the average durations of "taps" with respect to the five predictor variables.

Language and Distance from Code Switch

A linear mixed effects model (lmer) was run on the "tap" duration data (in seconds) with fixed effects of Language and Distance and random intercepts for Speaker.

Language: Spanish "taps" had a mean duration of 0.084 ms, while English "taps" had a mean duration of 0.030 ms. This difference was confirmed by a significant effect of Language, such that Spanish "taps" are longer than English "taps" (est.= 5.734e-02, t= 8.444, p= 1.57e-13). This result was expected, as Spanish [t]s are generally longer than English [ɾ]s.

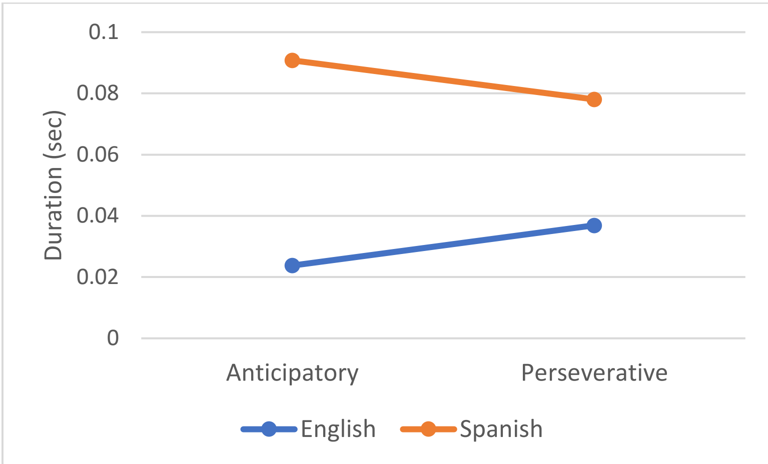
Distance: No effects or interactions of Distance were found for "tap" durations.

Direction

A second linear mixed effects model (lmer) was run on the "tap" duration data, adding Direction as an additional fixed effect and interaction factor. While there was not an independent effect of Direction on "tap" durations, there were two significant interactions with Direction.

Language x Direction interaction: There was a significant interaction between Language and Direction, such that Spanish anticipatory "taps" are longer than Spanish perseverative "taps", while English anticipatory "taps" are shorter than English perseverative "taps" (est.= -3.479e-02, t= -2.572, p= 0.012). See Figure 9 for means. This could indicate that before a code switch, Spanish "taps" are less tap-like; after a code switch, Spanish "taps" are more tap-like; before a code switch, English "taps" are more tap-like; and after a code switch, English "taps" are less tap-like. However, these influences are relative to the process causing the influence and whether the allophone is still in the normal range – in other words, being "less tap-like" might instead mean more stop-like.

Figure 9: Average "Tap" Duration by Language and Direction



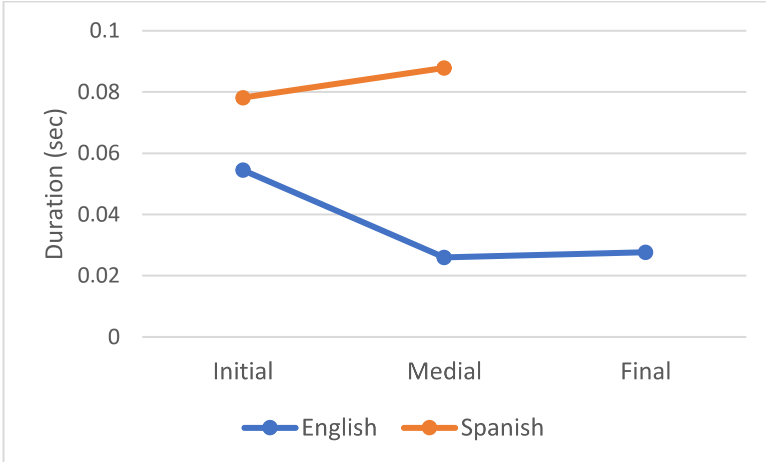
Position

Another linear mixed effects model (lmer) was run on the "tap" duration data, adding Position and Position interactions to the fixed effects of Language and Distance.

Position: Word-initial "taps" had a mean duration of 0.071 ms, while word-final "taps" had a mean duration of 0.024 ms. This difference was confirmed by a significant effect of Position, such that word-initial "taps" have a longer duration than word-final "taps" (est.= 3.355e-02, t= 2.566, p= 0.012). However, the following interaction provides a more accurate account.

Language x Position interaction: There was a marginal interaction between Language and Position, such that the duration of Spanish word-initial "taps" is not significantly different from that of Spanish word-medial "taps", while English word-initial "taps" are longer than English word-medial "taps", while (est.= -3.838e-02, t= -1.823, p= 0.071). See Figure 10 for means.

Figure 10: Average "Tap" Duration by Language and Position



Sentence Level

One more linear mixed effects model (lmer) was run on the “tap” duration data, adding Sentence Level and Sentence Level interactions to the fixed effects of Language and Distance. There were no significant effects of sentence level on the durations of “taps”, indicating that cross-language phonetic/phonological influence is equally likely to occur near intrasentential and intersentential code switches, at least with respect to tapping. Recall that the sentence level variable refers to type of code switch in which a token occurs (intersentential code switch or intrasentential code switch).

“Tap” Amplitude

Amplitudes of “taps” (intervocalic English /t/s and Spanish /t/s) were also examined to look for effects of code-switching on the phonetic/phonological realization of “taps”. English intervocalic /t/ is expected to be louder than Spanish intervocalic /t/ since it is canonically realized as [ɾ], and thus expected to be more tap-like, and taps are louder than stops. As I predict that tapping may increase in Spanish in closer proximity to a code switch (gradiently more tap-like and/or more categorical [ɾ] tokens), I expect Spanish “taps” to be louder closer to the code switch. As I predict that tapping may decrease in English closer to a code switch (gradiently less tap-like and/or fewer categorical [ɾ] tokens), I expect English “taps” to be quieter closer to the code switch. Below are the findings on the average amplitudes of “taps” with respect to the five predictor variables.

Language and Distance from Code Switch

A linear mixed effects model (lmer) was run on the “tap” amplitude data (in dB) with fixed effects of Language and Distance and random intercepts for Speaker.

Language: Surprisingly, there was not a significant effect of Language on the amplitude of “taps”, as the average amplitudes of Spanish “taps” and English “taps” are not significantly louder or quieter than each other. Spanish “taps” had a mean amplitude standard score of -0.625, while English “taps” had a mean amplitude standard score of 0.187. Spanish “taps” were expected to have a lower amplitude than English “taps”, as Spanish [t]s generally have a lower amplitude than English [ɾ]s. There are, however, two-way and three-way interactions with Language.

Distance*:* No independent effects of Distance from the code switch were found for “tap” amplitudes, as was the case with “tap” durations. However, there was an interaction with Distance, which will be discussed later.

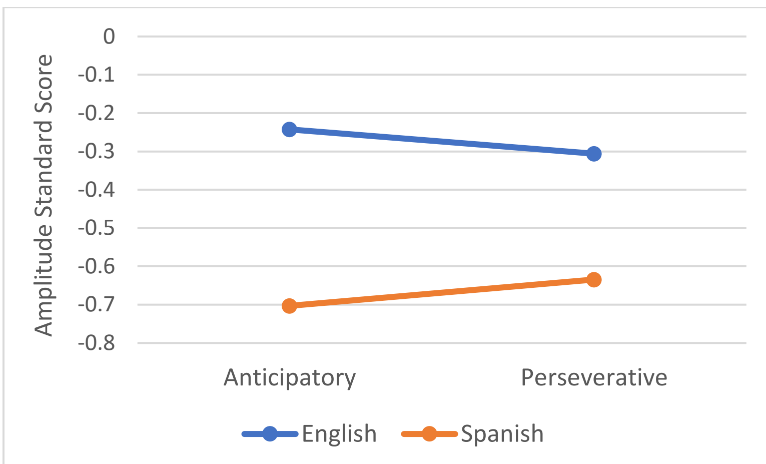
Direction

A second linear mixed effects model (lmer) was run on the “tap” amplitude data, adding Direction and Direction interactions to the fixed effects of Language and Distance.

Direction: No independent effects of Direction were found for “tap” amplitudes, but there was an interaction with Direction.

Language x Direction interaction: There was a significant interaction between Language and Direction, such that English anticipatory "taps" have a higher amplitude than English perseverative "taps", while Spanish anticipatory "taps" have a lower amplitude than Spanish perseverative "taps" (est.= 1.26683, t= 2.303, p= 0.023). See Figure 11 for means. As we saw with "tap" durations, this could indicate that after a code switch, English becomes less tap-like, and Spanish becomes more tap-like. There is a three-way interaction between Language, Direction, and Distance which provides a more accurate account (see below).

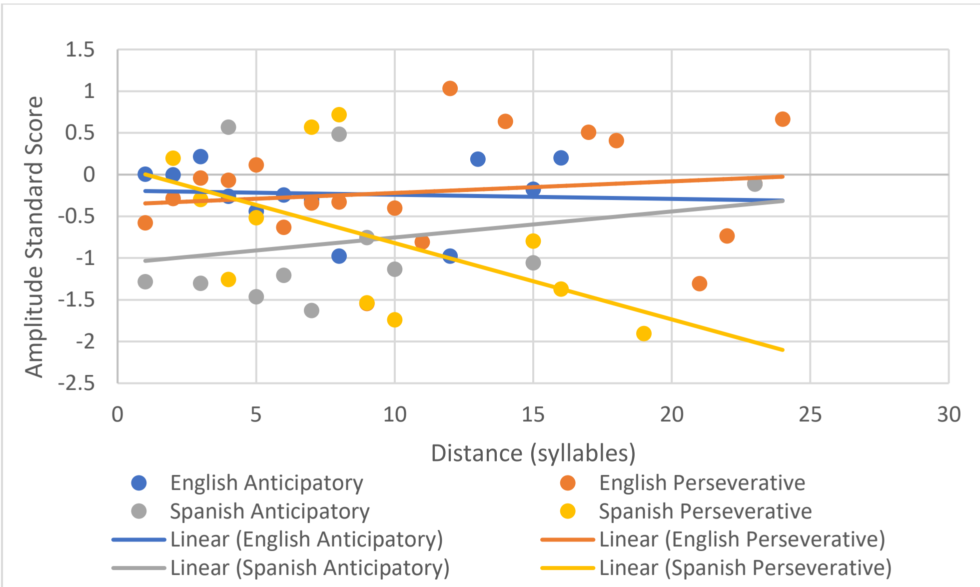
Figure 11: Average "Tap" Amplitude by Language and Direction



Language x Distance x Direction interaction: Although there was not a significant interaction between only Language and Distance from the code switch, there was a significant three-way interaction between Language, Distance, and Direction, such that the amplitude of Spanish anticipatory "taps" decreases closer to the code switch and the amplitude of Spanish perseverative "taps" increases closer to the code switch, while the amplitude of English anticipatory and perseverative "taps" are neither significantly different from each other nor affected by the distance from the code switch (est.= -0.16858, t= -2.568, p= 0.012). See Figure 12 for means. After a code switch, Spanish "taps" are more tap-like closer to the code switch;

before a code switch, Spanish "taps" are less tap-like (i.e., more stop-like) closer to the code switch.

Figure 12: Average "Tap" Amplitude by Language, Distance, and Direction

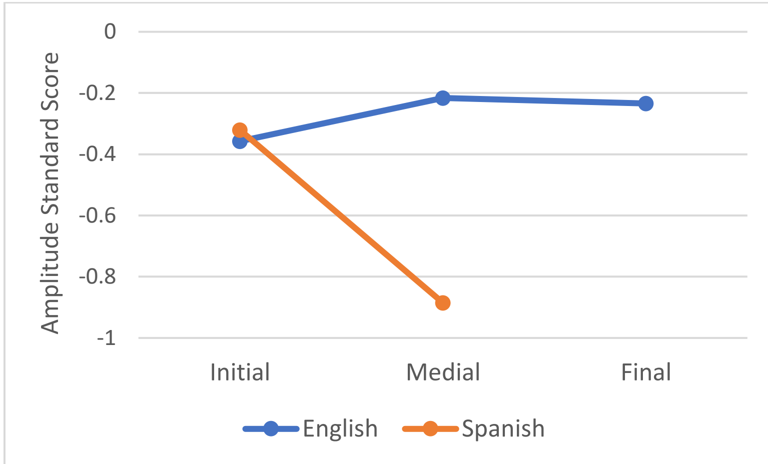


Position

Another linear mixed effects model (lmer) was run on the "tap" amplitude data, adding Position and Position interactions to the fixed effects of Language and Distance. Position was not found to have any independent effects on the amplitudes of "taps" but did have an interaction.

Language x Position interaction: There was a marginal interaction between Language and Position, such that English word-initial "taps" have a lower amplitude than word-medial "taps", while Spanish word-initial "taps" have a higher amplitude than Spanish word-medial "taps" (est.= 1.322253, t= 1.669, p= 0.098). See Figure 13 for means.

Figure 13: Average "Tap" Amplitude by Language and Position



Sentence Level

One more linear mixed effects model (lmer) was run on the "tap" amplitude data, adding Sentence Level and Sentence Level interactions to the fixed effects of Language and Distance. As was the case with the "tap" duration measurements, sentence level was not found to have any effects on the amplitudes of "taps", further indicating that cross-language phonetic/phonological influence with respect to tapping is equally likely to occur near intrasentential and intersentential code switches.

SPIRANTIZATION

Recall that I predict that spirantization may increase in English in closer proximity to a code switch, while spirantization may decrease in Spanish closer to a code switch. Table 4 below provides the number of "spirant" tokens per category for four of the five predictor variables. As a reminder, the term "spirants" refers to all intervocalic /d/s in both English and Spanish, except for those realized as Ø in Spanish. This includes those realized as [d] or [ɾ] in English and as [ð] in Spanish. For example, the tokens comprising this category include the /d/ in "to**d**ay," the /d/ in "we**dd**ing," and the /d/ in "na**d**a".

Table 4: "Spirant" Tokens Collected

	English Non-[ɾ]s	English [ɾ]s	Spanish	Spanish Deleted /d/s	Total
Anticipatory	29	14	46	31	120
Intersentential	20	10	31	20	81
Initial	15	7	18	8	48
Medial	3	1	13	12	29
Final	2	2	0	0	4
Intrasentential	9	4	15	11	39
Initial	4	1	7	4	16
Medial	4	2	8	7	21
Final	1	1	0	0	2
Perseverative	37	25	31	15	108
Intersentential	28	20	18	9	75
Initial	14	8	7	2	31
Medial	9	7	11	7	34
Final	5	5	0	0	10
Intrasentential	9	5	13	6	33
Initial	7	3	4	1	15
Medial	0	0	9	5	14
Final	2	2	0	0	4
Grand Total	66	39	77	46	228

“Spirant” Amplitude

Amplitudes of potential spirants (intervocalic English /d/s and Spanish /d/s), referred to as “spirants”, were examined to look for effects of code-switching on the phonetic/phonological realization of “spirants”. Spanish intervocalic /d/ is expected to have a lower amplitude than English intervocalic /d/ since it is canonically realized as [ð], and thus expected to be more eth-like, and fricatives are louder than stops. As I predict that spirantization may increase in English in closer proximity to a code switch (gradiently more eth-like and/or more categorical [ð] tokens), I expect English “spirants” to be louder closer to the code switch. As I predict that spirantization may decrease in Spanish closer to a code switch (gradiently less eth-like and/or fewer categorical [ð] tokens), I expect Spanish “spirants” to be quieter closer to the code switch.

Language and Distance from Code Switch

A linear mixed effects model (lmer) was run on the “spirant” amplitude data (in dB) with fixed effects of Language and Distance and random intercepts for Speaker. The reference level for Language was releveled to Spanish, as a previous model run with English as the reference level found very few effects for “spirant” amplitude.

Language: Spanish “spirants” had a mean amplitude standard score of 0.305, while English “spirants” had a mean amplitude standard score of -0.160. This difference was confirmed by a significant effect of Language, such that English “spirants” have a lower amplitude than Spanish “spirants” (est.= -0.71274, t= -2.935, p= 0.004). This was expected, as Spanish /d/s, realized as [ð], would generally have a higher amplitude than English /d/s, which would generally be realized as [d] or [ɾ].

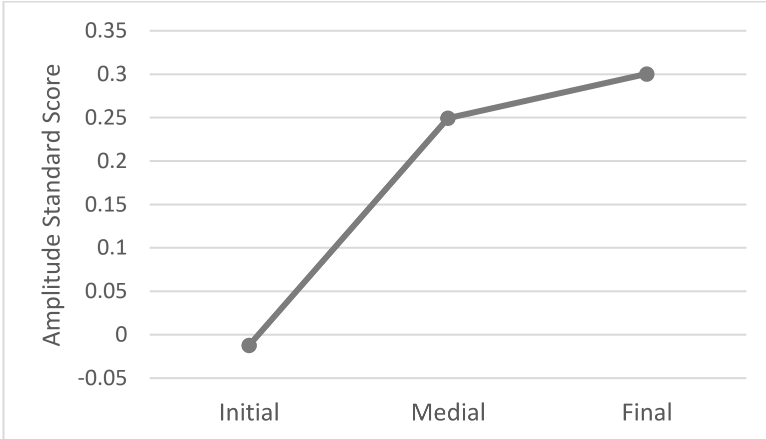
Distance: No individual effects of Distance from the code switch on the amplitudes of “spirants” were found. There were, however, two-way and three-way interactions with Distance.

Position

A second linear mixed effects model (lmer) was run on the “spirant” amplitude data, adding Position and Position interactions to the fixed effects of Language and Distance.

Position: There was a significant effect of Position, such that word-initial “spirants” have lower amplitude than word-final “spirants” (est.= -1.62093, t= -2.353, p= 0.020). See Figure 14 for means. As this effect includes both languages, it is not possible to interpret with regard to cross-language effects.

Figure 14: Average "Spirant" Amplitude by Position



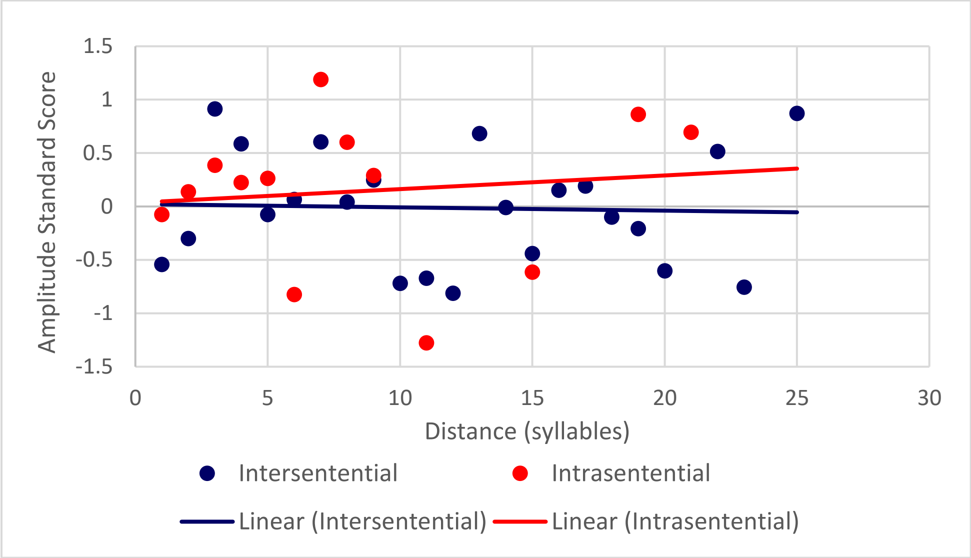
Sentence Level

Another linear mixed effects model (lmer) was run on the "spirant" amplitude data, adding Sentence Level and Sentence Level interactions to the fixed effects of Language and Distance.

Sentence Level: No individual effects of Sentence Level on the amplitudes of "spirants" were found. There were, however, two-way and three-way interactions with Sentence Level.

Distance x Sentence Level interaction: There was a significant interaction between Sentence Level and Distance from the code switch, such that the amplitude of "spirants" from intrasentential switches decreases as the distance from the code switch decreases, while the amplitude of "spirants" from intersentential switches does not change significantly (est.= -0.08556, t= -2.128, p= 0.035). See Figure 15 for means. This would indicate that "spirants" from intrasentential switches are less eth-like closer to the code switch; however, there is a three-way interaction between Language, Distance, and Sentence Level which provides a more accurate account (see below).

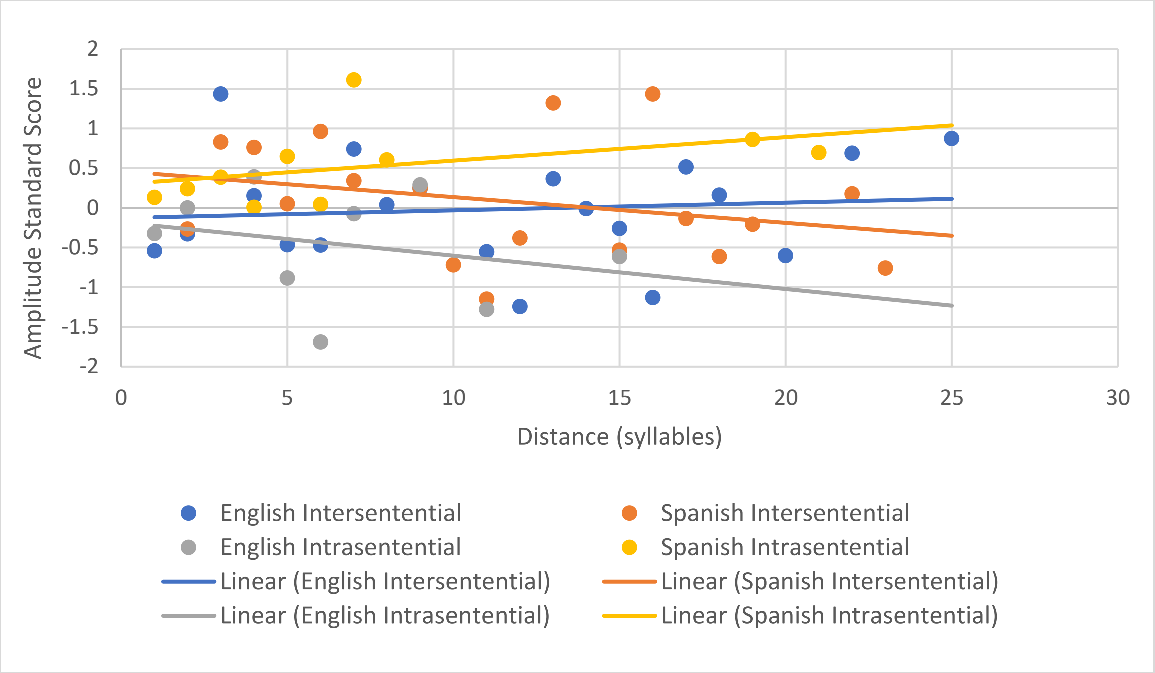
Figure 15: Average "Spirant" Amplitude by Distance and Sentence Level



Language x Distance x Sentence Level interaction: There was a significant interaction between Language, Distance from the code switch, and Sentence Level, such that the amplitude of English “spirants” from intersentential switches decreases as the distance from the code switch decreases, while the amplitude of English “spirants” from intrasentential switches increases as the distance from the code switch decreases, and such that the amplitude of Spanish “spirants” from intersentential switches increases as the distance from the code switch decreases, while the amplitude of Spanish “spirants” from intrasentential switches decreases as the distance from the code switch decreases (est.= 0.15008, t= 2.143, p= 0.034). See Figure 16 for means.

Therefore, closer to an intrasentential code switch, Spanish "spirants" are less eth-like and English "spirants" are more eth-like. Closer to an intersentential code switch, Spanish "spirants" are more eth-like, and English "spirants" are less eth-like. Unexpectedly, however, the amplitudes converge near the code switch; if the far points were the canonical realization of the allophones and increasing proximity to the code switch influenced the amplitude, as predicted, we would expect the far points to converge (within each language) and the near points to differ.

Figure 16: Average "Spirant" Amplitude by Language, Distance, and Sentence Level



Direction

One more linear mixed effects model (lmer) was run on the "spirant" amplitude, adding Direction and Direction interactions to the fixed effects of Language and Distance. The amplitude of "spirants" was not shown to be influenced by Direction in any way, indicating that cross-language phonetic/phonological influence is equally likely to occur in anticipation of a code switch and as a carryover effect, with respect to spirantization.

3.2 DOMINANT LANGUAGE IN A CONVERSATION

Recall that dominant language in a conversation is an added factor that refers to the dominance of a language in each conversation, with respect to the degree of English dominance (approximately 50% English dominant, 70% English dominant, or 90% English dominant). The effect of the dominant language of the conversations clarifies the effects of language on the patterns of cross-language influences. The effects for each dependent measure are as follows.

"TAP" DURATION

A linear mixed effects model (lmer) was run on the "tap" duration data (in seconds) with fixed effects of Language, Distance, and Dominance; random intercepts for Speaker; and the reference level for Language changed back to English. No effects of Dominance were found for "tap" durations.

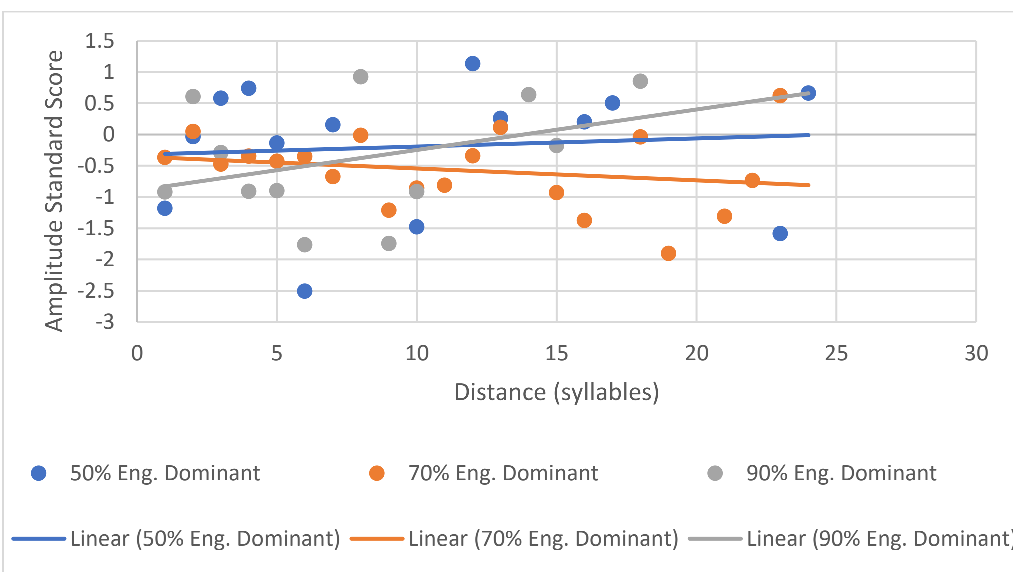
"TAP" AMPLITUDE

A linear mixed effects model (lmer) was run on the "tap" amplitude data (in dB) with fixed effects of Language, Distance, and Dominance and random intercepts for Speaker.

Dominance x Distance interaction

There was a marginal interaction between Dominance and Distance from the code switch between 50% English dominance and 70% English dominance (est.= -0.07840, t= -1.824, p= 0.0712). See Figure 17 for means. There is a three-way interaction between Language, Dominance, and Distance which provides a more accurate account (see below).

Figure 17: Average "Tap" Amplitude by Dominance and Distance



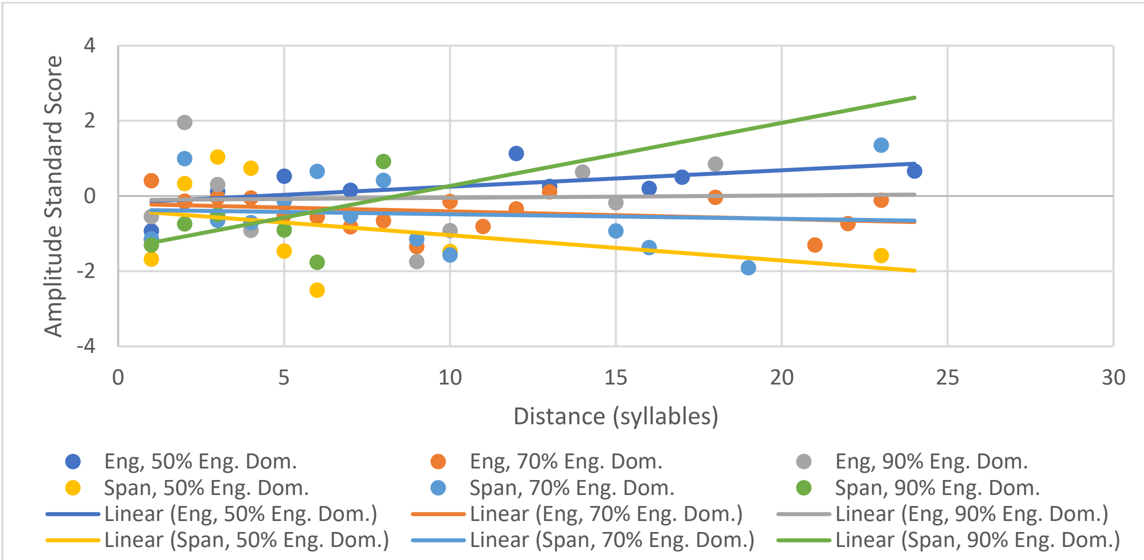
Language x Dominance x Distance interaction

There was a significant interaction between Language, Dominance, and Distance from the code switch between 50% English dominance and 70% English dominance (est.= 0.15534, t= 2.181, p= 0.032). There was also a marginal interaction between Language, Dominance, and Distance between 50% English dominance and 90% English dominance (est.= 0.27325, t= 1.745, p= 0.084). See Figure 18 for means.

This interaction is not fully interpretable. For Spanish, as the degree of English dominance increases, the amplitudes of "taps" far from the code switch increases, while English does not have any equivalent linear pattern. Furthermore, the only identifiable linear pattern with respect to distance-based changes is in the three categories of the amplitude of Spanish "taps", but the 90% English dominance category (the green line) does not have any tokens after 8 syllables, making the slope unreliable. Thus, no conclusions can be made about effects of a dominant language on "tap" amplitudes.

Surprisingly, again, nearly all categories converge at the 1-syllable point (the point closest to the code switch); if the distance from the code switch were causing the changing degrees of amplitude for "taps", it would be expected that the far points would be similar within each language and the varying degrees of influence would result in differing amplitudes near the code switch. This supports the conclusion that there is no effect of dominant language.

Figure 18: Average "Tap" Amplitude by Language, Dominance, and Distance



"SPIRANT" AMPLITUDE

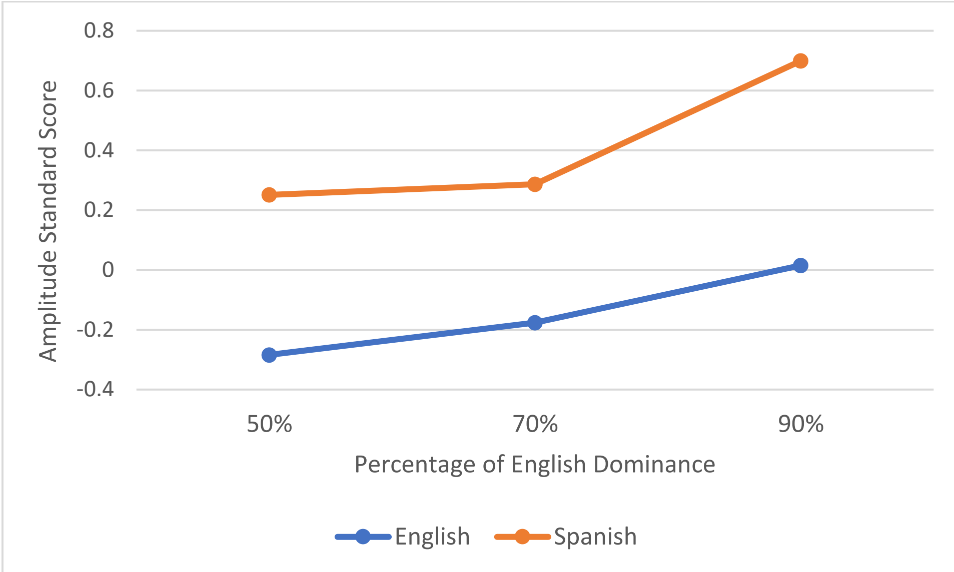
A linear mixed effects model (lmer) was run on the "spirant" amplitude data (in dB) with fixed effects of Language, Distance, and Dominance and random intercepts for Speaker.

Language x Dominance interaction

There was a marginal interaction between Language and Dominance between 50% English dominance and 90% English dominance, such that the amplitude of Spanish "spirants" increases as the degree of English dominance increases, while the amplitude of English "spirants" is not significantly influenced by the degree of English dominance (est.= 1.86055, t= 1.776, p= 0.078). See Figure 19 for means.

This indicates that Spanish "spirants" are more eth-like when the conversation is more English dominant, while the English dominance of the conversation does not affect the degree of spirantization of English /d/s. However, there is a three-way interaction between Language, Dominance, and Distance which provides a more accurate account (see below).

Figure 19: Average "Spirant" Amplitude by Language and Dominance

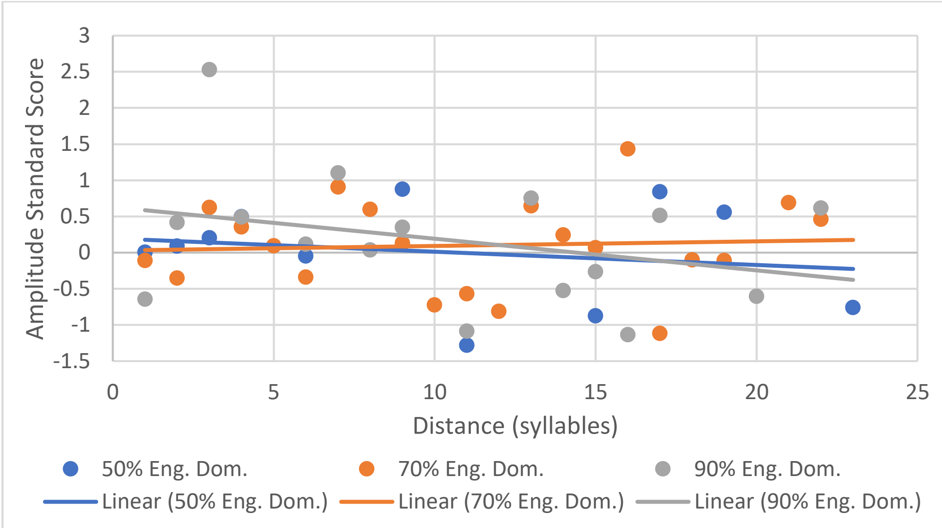


Dominance x Distance interaction

There was a marginal interaction between Dominance and Distance from the code switch between 50% English dominance and 70% English dominance, such that the amplitude of “spirants” in the 50% English dominant conversation increases closer to the code switch, while the amplitude of “spirants” in the 70% English dominant conversation decreases closer to the code switch (est.= 0.14539, t= 1.752, p= 0.082). See Figure 20 for means.

However, as seen in Figure 20, the amplitude of “spirants” in the 90% English dominant conversation also increases closer to the code switch, indicating that the degree of English dominance of a conversation does not linearly affect the “spirant” amplitudes and that the marginal interaction between Dominance and Distance just occurred by chance. Again, however, there is a three-way interaction between Language, Dominance, and Distance which provides a more accurate account (see below).

Figure 20: Average "Spirant" Amplitude by Dominance and Distance



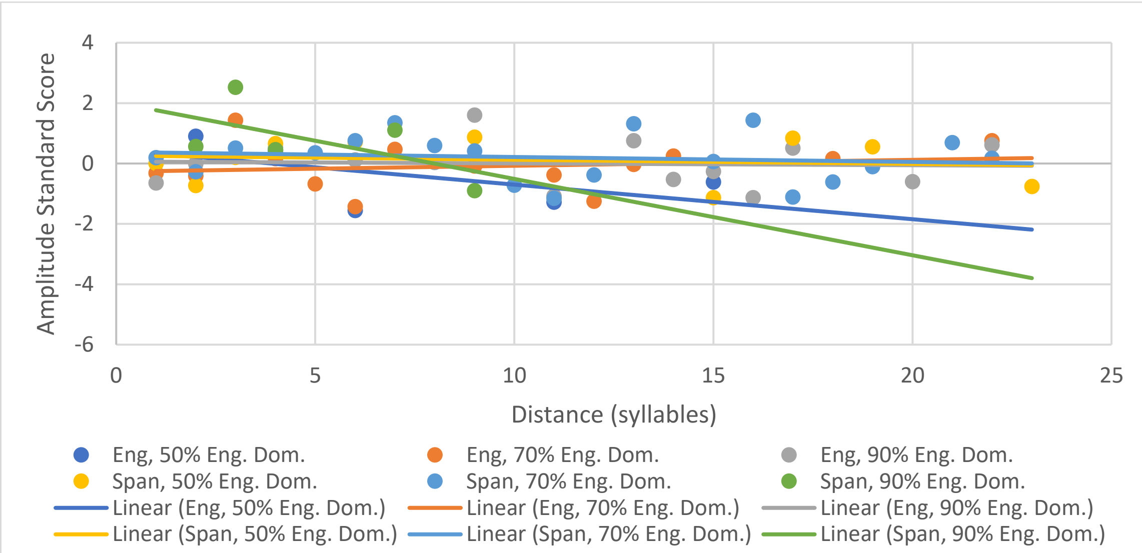
Language x Dominance x Distance interaction

There was a marginal interaction between Language, Dominance, and Distance from the code switch between 50% English dominance and 90% English dominance, such that English “spirants” in the conversation with the lowest degree of English dominance get louder closer to the switch, and the effect of dominant language disappears as the English dominance increases, while Spanish “spirants” in the conversation with the highest degree of English dominance get louder closer to the code switch, and the effect of dominant language disappears as the English dominance decreases (est.= -0.29106, t= -1.850, p= 0.067). See Figure 21 for means.

English “spirants” in the conversation with the lowest degree of English dominance are less spirant-like than the other degrees of English dominance and get more spirant-like closer to the switch. Spanish “spirants” in the conversation with the highest degree of English dominance are less spirant-like than the other degrees of English dominance get more spirant-like closer to the code switch. This could indicate that lower English dominance makes English “spirants” more prone to influence from Spanish spirantization, and higher English dominance makes

Spanish “spirants” “more Spanish-like”, meaning English dominance has opposite effects on each language with respect to increasingly Spanish-like realization, but there would be no logical explanation for that. Due to the lack of a sensible pattern, no conclusions can be made about effects of dominant language on “spirant” amplitudes.

Figure 21: Average "Spirant" Amplitude by Language, Dominance, and Distance



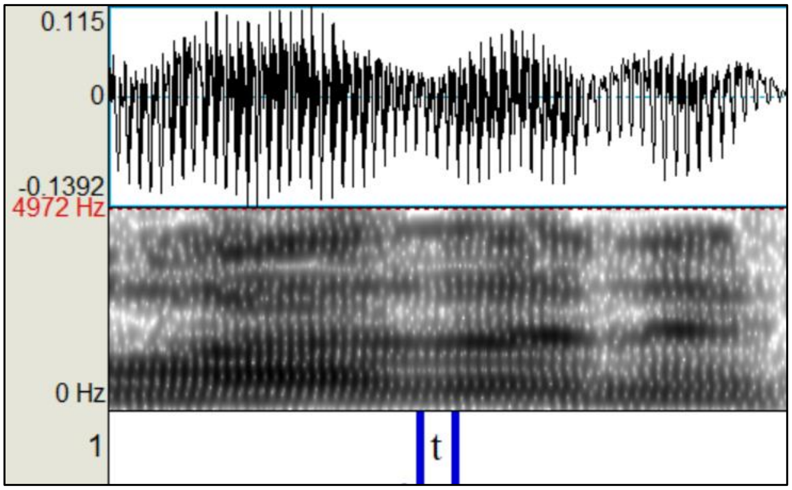
3.3 CATEGORICAL INFLUENCE

Recall that categorical influence tokens are those that are fully influenced by the other language’s process or lack of process, where one language applies the other language’s process or fails to apply its own process. Their presence would indicate whether a full cross-language transfer of a phonological process can occur in code-switching. And for the gradient influences found, the number of categorical tokens will determine whether the means were only affected by the presence of tokens with categorical influence or by many tokens with phonetically gradient influences on duration and amplitude. Approximately 1% of the tokens in the data were found to have a categorical influence and were found in both processes and both languages. As was done in the analysis of gradient influences, categorical influence tokens were analyzed with respect to five variables: language (Spanish or English), distance from the code switch (number of syllables from the code switch), direction (anticipatory (before the code switch) or perseverative (after the code switch)), sentence level (intersentential or intrasentential), and position (word-initial, word-medial, or word-final). Below are examples of each type of categorical phonological process influence. Audio clips of the following tokens can be found in Appendix C.

CATEGORICAL INFLUENCE EXAMPLE #1: TAPPING PROMOTION

In the case below, we see the categorical influence of the tapping process in Spanish, wherein the intervocalic /t/ followed by an unstressed vowel (the canonical tapping context), is realized as [ɾ]. In this example, the token was found in the words "a **t**ener" from the line "pero las fotos vas a **t**ener que hacerlas más chiquitas para que (unintelligible)". This token came from speaker #5, was 7 syllables away from the code switch, and was a perseverative, intersentential, word-initial token.

Figure 22: Categorical Influence Example #1: Tapping Promotion

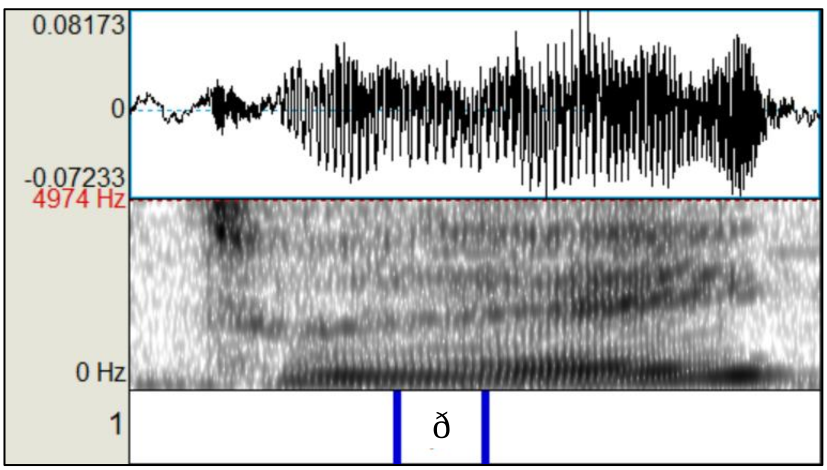


In the spectrogram in Figure 22 above, none of the previously mentioned criteria for [t]s – voicelessness, closure, a burst – can be seen in this token, and the duration does not appear to be a typical [t] duration. Instead, this token has the characteristics of a [ɾ]: voicing, moderate amplitude than can be easily distinguished from the more intense surrounding vowels (primarily in F3, in this case), and a duration typical of a [ɾ].

CATEGORICAL INFLUENCE EXAMPLE #2: SPIRANTIZATION PROMOTION

In the case below, we see the categorical influence of the spirantization process in English, wherein the intervocalic /d/ is realized as [ð] (and produced more like an approximant). In this example, the token was found in the word "today" from the line "for example you know like for instance today ya yo tengo rosetti". This token came from speaker #4, was 1 syllable away from the code switch, and was an anticipatory, intrasentential, word-medial token.

Figure 23: Categorical Influence Example #2: Spirantization Promotion



The token in the spectrogram in Figure 23 above does not meet any of the criteria for [d], aside from voicing. There is not a closure, burst, or clear demarcation from the surrounding vowels. Rather, we see the characteristics of [ð]: an amplitude and formant structure similar to those of the surrounding vowels, and little to no clear demarcation between it and the vowels.

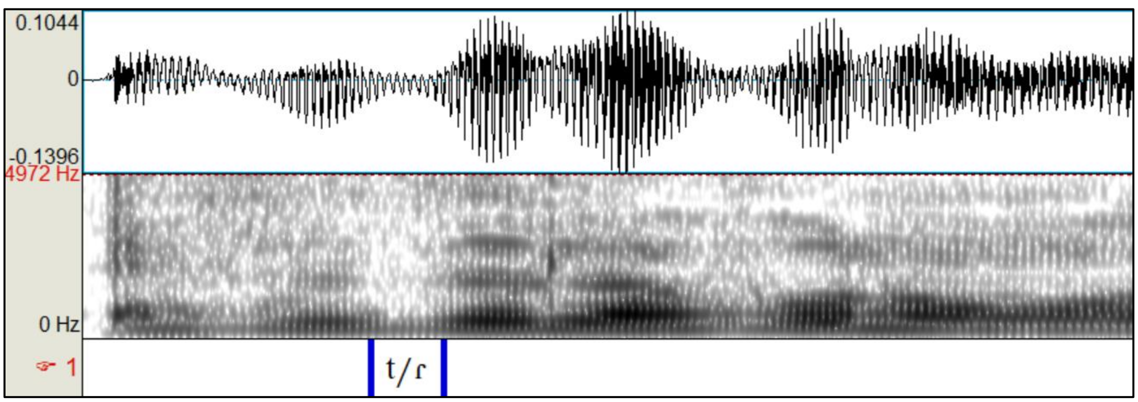
3.4 HALFWAY INFLUENCE

Approximately 2% of tokens in the data were found to have a halfway influence. Recall that these are tokens with strong degree of gradient influence, to the point that the token appears to be halfway between the expected, canonical allophone and the code switch-motivated target allophone.

HALFWAY INFLUENCE EXAMPLE #1- TAPPING PROMOTION

In the case below, we see the halfway influence of the tapping process into Spanish, wherein the intervocalic /t/ followed by an unstressed vowel is produced as a fusion of [t] and [ɾ]. In this example, the token was found in the words "este teléfono" from the line "este teléfono me vuelve". This token came from speaker #5, was 3 syllables away from the code switch, and was a perseverative, intersentential, word-initial token.

Figure 24: Halfway Influence Example #1: Tapping Promotion

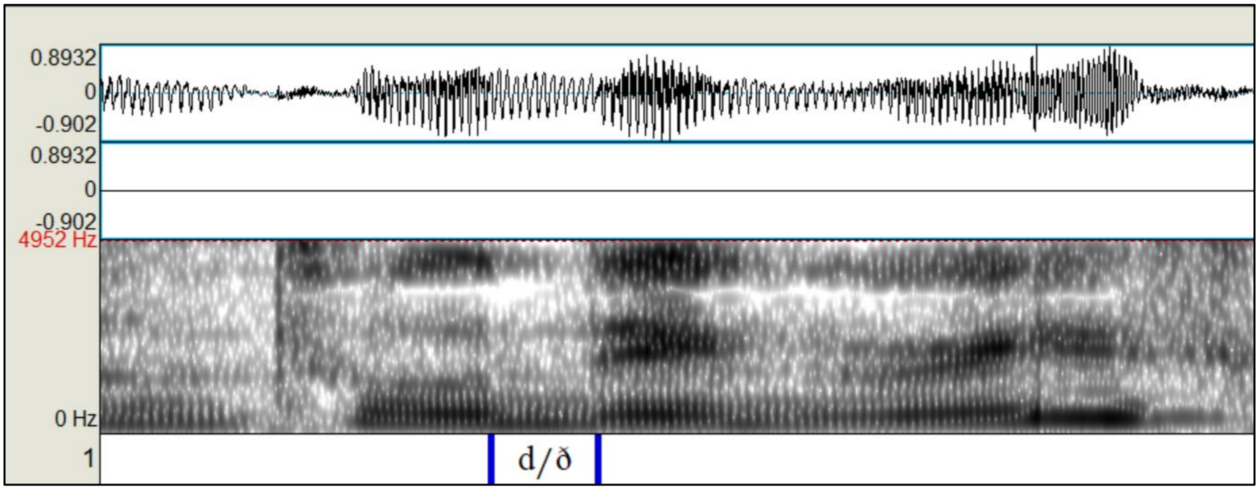


The token in the spectrogram in Figure 24 above has a duration that is more typical of a [t], and the low amplitude in the center of the sound indicates a closure. However, it also has voicing and does not have a burst, which are criteria of [ɾ]s. This indicates that the sound is tapping to a significant degree such that the tapping process is being applied halfway.

HALFWAY INFLUENCE EXAMPLE #2: SPIRANTIZATION PROMOTION

In the case below, we see the halfway influence of the spirantization process into English, wherein the intervocalic /d/ is produced as a fusion of [d] and [ð]. In this example, the token was found in the words "two **d**egrees" from the line "bueno por lo menos subió two degrees cause it used to be sixty-one". While this token is in both a Spanish spirantization context and an English tapping context, the spirantization process is overriding the tapping process, causing the /d/ to become more spirant-like rather than a [ɾ] or more tap-like. This token came from speaker #1, was 2 syllables away from the code switch, and was a perseverative, intrasentential, word-initial token.

Figure 25: Halfway Influence Example #2: Spirantization Promotion

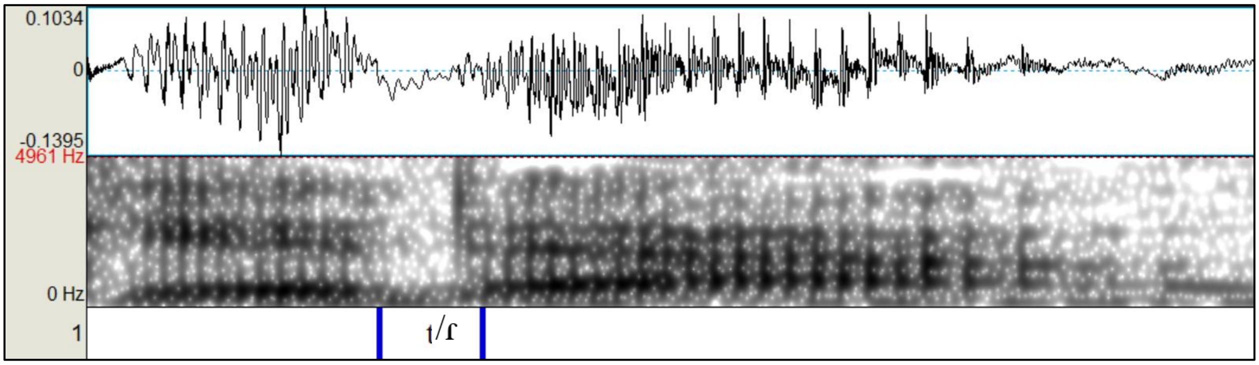


In the spectrogram in Figure 25 above, we can see that the sound has voicing and a period of lower amplitude compared to that of the surrounding vowels, both of which are characteristics of both [d] and [ð]. This sound also has a burst, which is characteristic of [d]. However, the sound does not have the closure of a [d]; instead, there is frication, which is characteristic of [ð]. This indicates that the sound is spirantizing to a significant degree such that the spirantization process is being applied halfway.

HALFWAY INFLUENCE EXAMPLE #3: TAPPING INHIBITION

In the case below, we see the weakening of the tapping process in English, wherein the intervocalic /t/ followed by an unstressed vowel does not undergo the tapping process and is instead realized as a [t]. In this example, the token was found in the words "it out" from the line "and we try to work it out". This token came from speaker #4, was 2 syllables away from the code switch, and was an anticipatory, intersentential, word-final token.

Figure 26: Halfway Influence Example #3: Tapping Inhibition

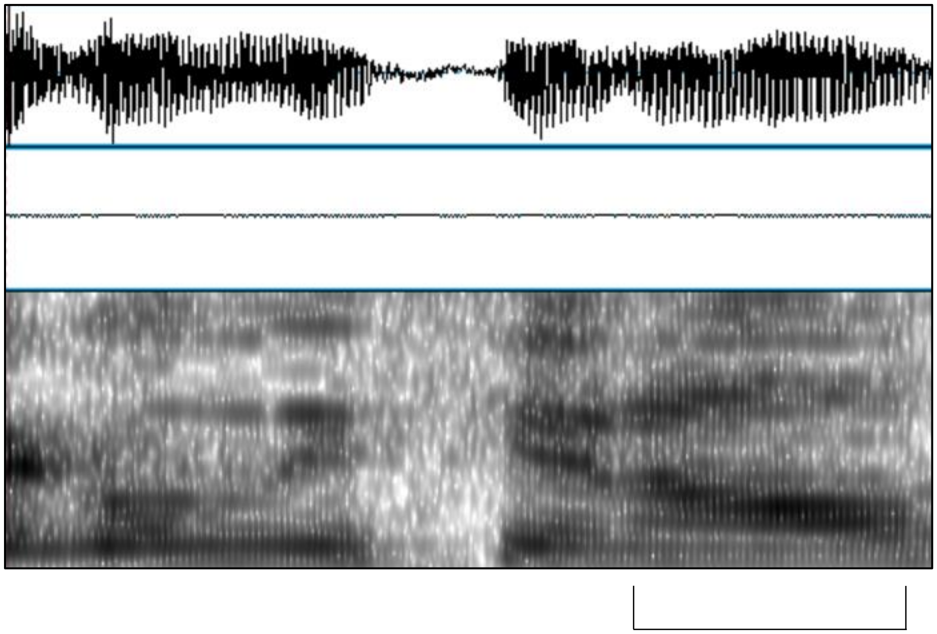


The token as seen in the spectrogram in Figure 26 above has the closure and burst characteristic of a stop. It also has voicing, however, which is characteristic of [ɾ]. This indicates that the tapping process is not being fully applied and the sound is only tapping halfway.

3.5 DELETED /d/S

As previously noted, 47 intervocalic Spanish /d/s were realized as ∅. Approximately 34% of these tokens occurred within 3 syllables from the code switch, which corresponds to the probabilistic likelihood based on the distribution of all tokens, meaning that distance from a code switch does not appear to have an effect of whether a Spanish intervocalic /d/ is realized as ∅. Additionally, 75% of these tokens were anticipatory, and approximately 63% occurred in intersentential code switches. Figure 27 provides an example of this in the spectrogram of the word *acondicionado,* of which the second /d/ is realized as ∅. The marked section denotes the -*ado* ending; note that in this section there only appear to be vowels, not a [d] or an [ð]. Additionally, Appendix B provides a list of the contexts in which each of these tokens occur.

Figure 27: Deleted Spanish /d/ in Spectrogram



3.6 GRADIENT INFLUENCE VERSUS CATEGORICAL INFLUENCE CONCLUSION

While categorical and halfway influences were found to occur, there was only a small number of these tokens. This suggests that these tokens did not significantly affect the means of the gradient influences, which indicates that the means were the result of a significant number of tokens with a gradient, low-level phonetic influence. Thus, cross-language influence occurs as both a low-level phonetic influence and a categorical phonological influence.

4. DISCUSSION

Recall our hypotheses again: 1) English /t/ tapping makes Spanish /t/ more tap-like near a code switch, 2) Spanish /d/ spirantization makes English /d/ more eth-like near a code switch, 3) English /t/ tapping is not fully realized in English near a code switch to/from Spanish, 4) Spanish /d/ spirantization is not fully realized in Spanish near a code switch to/from English, and 5) cross-language influences are stronger closer to a code switch (i.e., as the distance from the switch decreases, the influence increases). Below is a discussion of the current study's findings with respect to these hypotheses.

4.1 GRADIENT INFLUENCE

Findings show that the code-switching context encourages gradient effects in "taps" and "spirants" due to the influence of the other language's phonological process and the influence of either the lack thereof or the differing systems of contrast. This means that this context causes these sounds to become slightly more or less tap-like or spirant-like, without becoming a categorically distinct allophone or a realization halfway in between the canonical allophone and the code switch-motivated target allophone.

TAPPING

Recall that "tap" durations and amplitudes were affected by the variables of direction, position, and sentence level. "Tap" durations were also affected by the language variable, and "tap" amplitudes were also affected by the distance variable.

"Tap" Duration and Amplitude Summary

In Spanish, we see a possible influence from English on perseverative tokens, meaning that the cross-language influence of the tapping process only significantly applies *after* a code-switch, not before. In other words, Spanish seems to become more tap-like after code switches, compared to before the code switch, potentially supporting hypothesis 1 and indicating that the English tapping process is making Spanish /t/s more tap-like. This is indicated by the significant effects of language and direction on "tap" duration and language, direction, and distance on "tap" amplitude. Additionally, "tap" amplitudes are affected by distance after the code switch, such that perseverative Spanish "tap" amplitudes have a residual effect from English that weakens over time during the turn.

It is worth noting, however, that Spanish anticipatory “taps” are less tap-like (in duration and amplitude), in comparison to perseverative “taps,” and become less tap-like closer to the code switch. Also, English “taps” are more tap-like before a code switch (in both duration and amplitude). These unexpected, unexplainable patterns indicate that the patterns of Spanish /t/s becoming more tap-like might not be due to the causes predicted. One possible explanation is that the languages might hyperarticulate their canonical allophone in anticipatory tokens. This would mean that anticipatory Spanish “taps” are trying to be “more Spanish” in anticipation of a code switch, and English “taps” are trying to be “more English” in anticipation of a code switch, which could be due to the desire to distinguish themselves from the upcoming language.

Additionally, both languages potentially have the influences predicted in hypotheses 1 and 3 in the word-initial position only, for both “tap” durations and amplitudes, as English word-initial “taps” are less tap-like than word-final “taps” (to the point of exceeding the normal tap duration range), and Spanish word-initial “taps” are more tap-like than word-medial “taps”. Additionally, the two languages have similar values at the word-initial position, while the word-medial positions have a significant difference, indicating that their convergence in word-initial positions may be due to the cross-language influence; however, this does not necessarily support hypotheses 1 and 3 as there are other possible causes for these effects.

Findings show that while the “taps” in each language have expectedly different durations (in Spanish, durations closer to typical [t] durations; in English, durations closer to typical [ɾ] durations), they unexpectedly do not have significantly different amplitudes in most of the statistical model. In other words, English “taps” (primarily [ɾ]s) were not louder than Spanish “taps” (primarily [t]s), which was unexpected. The only model to show a language effect for “tap” amplitudes was the model that included the position variable. However, as we saw in the interaction between language and position, the durations and amplitudes of the two languages converge in the word-initial position; as we can see that there is a notable difference between languages in the word-medial position (see Figures 10 and 13), we can conclude that the lack of accounting for position in the other models caused the lack of difference in the word-initial position to obscure the natural difference between the languages' "tap" amplitudes. Moreover, regarding the distance variable, it is unclear why "tap" amplitudes are slightly affected but "tap" durations are not.

In sum, the results for "tap" duration and "tap" amplitude greatly correlate regarding the variables and their effects. The direction variable influences both "tap" measures such that the tokens that undergo the predicted hypotheses are perseverative tokens, and the position variable possibly influences both "tap" measures such that word-initial tokens are influenced by the code switch. The high number of inverse/matching patterns between the "tap" duration and "amplitude" measurements supports the interpretation that this does mean the sound is becoming more tap like, not just louder or longer for other reasons.

Tapping Conclusion

Perseverative "taps" and word-initial "taps" appear to receive cross-language influence with respect to hypothesis 1 and possibly hypothesis 3, such that the English /t/ tapping process is influencing the realization of Spanish [t]s by making them more tap-like, and Spanish's lack of tapping may be inhibiting the realization of English /t/s by making them less tap-like. Thus, these results show a prohibiting effect and potentially an inhibiting effect, and importantly, both languages see a relatively equal influence from the other, meaning that there is a symmetrical exertion of force, which will be further discussed later. Finally, as the variable of direction is inherently based upon code-switching, it appears that the code switch is affecting the cross-language influence seen here.

SPIRANTIZATION

These findings indicate the potential for cross-language influence on spirantization, which will now be examined. Recall that "spirant" amplitudes were affected by the variables of language, distance, sentence level, and position.

"Spirant" Amplitude Summary

As expected, Spanish "spirants" (primarily [ð]) are louder than English "spirants" (primarily [d] or [ɾ]). The languages also differed in how the sentence level of the code switch in which the token occurs (intersentential or intrasentential) interacts with the distance from the code switch. English intrasentential "spirants" become more spirant-like closer to the switch, supporting hypothesis 2 and indicating that English /d/s are possibly being influenced by Spanish's /d/ spirantization process. Spanish intrasentential "spirants" become less spirant-like closer to the code switch, supporting hypothesis 4 and indicating that Spanish /d/s are possibly being influenced by the English code switch (because of English's lack of /d/ spirantization and/or its contrastive relationship between /d/ and /ð/).

Unexpectedly, however, closer to the switch, Spanish intersentential "spirants" become more spirant-like, and English intersentential "spirants" become less spirant-like. This could indicate that in anticipation of a code switch both languages hyperarticulate their canonical allophone, so that Spanish "spirants" would sound more "Spanish-like" and English "spirants" would sound more English-like. It is unclear, however, why the sentence level would affect this, indicating that these patterns might be due to chance or other causes.

For both languages, “spirants” in the word-initial position were quieter than word-final “spirants”. The same effect occurring in both languages and the fact that position is not a variable inherently related to code-switching indicate that these effects are presumably unrelated to code switch-motivated phonetic/phonological influences.

Spirantization Conclusion

We see that intrasentential word-initial “spirants” undergo cross-language influence with respect to hypotheses 2 and 4, such that the Spanish /d/ spirantization process is possibly influencing the realization of English [d]s by making them more eth-like, and English is possibly inhibiting the Spanish /d/ spirantization process by making Spanish /d/s more stop-like. In spirantization, as in tapping, potential promoting and inhibiting effects are both found, and both languages influence/are influenced to an approximately equal degree. Finally, as the variable of sentence level is inherently based upon code-switching, it appears that the code switch is affecting the cross-language influence seen here.

It is worth noting that while the lack of the spirantization process in English may have inhibited the process in Spanish – making intervocalic Spanish /d/s less spirant-like and more stop-like – the tapping process of English (/d/ → [ɾ]) may have been promoted into Spanish – making intervocalic Spanish /d/s less spirant-like and more tap-like. Overall, it appears that these tokens are becoming more stop-like, indicating that the Spanish spirantization process is indeed being inhibited. However, it is possible that while the spirantization process is being inhibited, the tapping process is also simultaneously being promoted. As stops are quieter than spirants, and taps are louder than spirants, the effects of spirantization inhibition and tapping promotion might partially cancel each other out, making it impossible to decipher exactly what is occurring here. However, if this is indeed the case, it could be speculated that the degree/frequency of inhibiting effects may have been stronger had there not been another phonological process potentially competing with it in the realization of these tokens.

GRADIENT INFLUENCE CONCLUSION

The presence of these patterns shows that cross-language phonological influence is realized phonetically gradiently. In total, the presence of various gradient influences provides potential support for all five hypotheses. Overall, the gradient influences provide support for both promoting effects and inhibiting effects, and both languages appear to influence/be influenced to the same degree, indicating that there are no language-based asymmetries.

4.2 CATEGORICAL INFLUENCE AND HALFWAY INFLUENCE

The gradient effects discovered could be truly gradient, or they could be affected by the durations and amplitudes of tokens with categorical influence. To determine which is the case, I examined the tokens with categorical influences.

CATEGORICAL INFLUENCE

In addition to the gradient influences, wherein English /d/ and Spanish /t/ become phonetically more eth-like and tap-like, respectively, the current study also found tokens with a categorical influence, wherein intervocalic English /d/ is realized as [ð] and intervocalic Spanish /t/ is realized as [ɾ]. The presence of these tokens indicates that intervocalic /d/ spirantization can transfer to English, and intervocalic /t/ tapping can transfer to Spanish. This further supports hypotheses 1 and 2, confirming that phonological processes can be promoted cross-linguistically, and this indicates that categorical influence is one form of cross-language phonological influence.

HALFWAY INFLUENCE

The presence of tokens in which intervocalic English /d/ is halfway applied to Spanish and intervocalic Spanish /t/ is halfway applied to English further support hypotheses 1 and 2 by confirming that cross-language promoting effects of phonological processes can occur. This also indicates more generally that a gradient effect to the extent of becoming a combination halfway between the canonical allophone and code switch-motivated target allophone can occur.

The presence of tokens in which intervocalic English /t/ is realized as a sound halfway between [t] and [ɾ], instead of the canonical [ɾ] further supports hypothesis 3 by confirming that cross-language influence (from Spanish's lack of tapping and/or phonemic contrast of /ɾ/) can inhibit the application of the tapping process in. This also indicates more generally that a gradient effect to the extent of becoming a combination halfway between the expected canonical allophone and the code switch-motivated allophone (in this case the underlying phoneme) can occur.

DISCUSSION

As we can see, there are significantly more categorical and halfway tokens that are influenced by the promoting effects with a much smaller number of tokens influenced by an inhibiting effect. Additionally, we see both promoting effects (English influenced by spirantization and Spanish influenced by tapping) but only one of the inhibiting effects (English tapping inhibited) in these tokens.

As previously noted, the number of categorical influence and halfway influence tokens found was rather small. This raises the question of why some of these tokens fully apply the opposite language's phonological process, while most tokens only show at most minute gradient influences of them. It is possible that there is a factor determining to which tokens this influence applies. Potential factors have been considered and are discussed in detail below.

Speakers

All five speakers were found to have at least one token with a categorical influence or halfway influence. Although the tokens with a categorical or halfway influence are infrequent, their pervasiveness across speakers suggests that this cross-language transfer of phonological processes is not just idiosyncratic. We can thus conclude that it is an uncommon yet systematic phenomenon, at least for female balanced Spanish-English bilinguals.

Distance from Code Switch

For each of these tokens, the distance from the code switch was considered as a potential motivator for tokens in one language to be categorically or halfway influenced by the other language's phonological process, lack thereof, or phonemic contrast.

Hypotheses 1 and 2: Promoting the Cross-language Application of Phonological Processes

Nearly all the tokens that have a categorical or halfway application of the opposite language's phonology in relation to hypotheses 1 and 2 are within three syllables from the code switch, suggesting that the close proximity of one to three syllables from a code switch is conducive to cross-language phonological influence. For the full set of tokens, there is an approximately 30% likelihood that any given token would fall within three syllables from the code switch. Thus, if this specific proximity were not a motivator, only approximately one third of the categorical and halfway tokens should have occurred within three syllables from the switch, while instead approximately 80% of these tokens are within this range. Therefore, it is fair to conclude that it is not a matter of coincidence that categorical and halfway tokens nearly always appear in this range.

Moreover, it is not the case that all tokens within three syllables from the switch fully apply the opposite language's phonological process. Thus, while being within three syllables from the switch might be an important factor in motivating categorical or halfway influence, it can be presumed that it is not the only necessary factor. Therefore, we must consider whether another factor is partially responsible for determining when this cross-language categorical application of a phonological process occurs.

Hypothesis 3: Inhibiting the Application of the Tapping Process in English

The categorical or halfway inhibition of the tapping process (in both /t/s and /d/s) in English happens across a wide range of proximities to the code switch; thus, the distance from the code switch does not seem to determine when this weakening happens. As a result, it is not possible to say whether this is an effect of the general code-switching context or is just a feature of bilingual speech more generally.

Other Variables

There do not appear to be any patterns of the direction, position, and sentence level variables with respect to which tokens undergo a categorical or halfway influence from the opposite language. However, due to the small number of categorical and halfway tokens, we cannot conclude that these variables would not generally be significant in determining which tokens undergo these forms of influence.

Word Class

The word classes of the words in which these tokens occurred were also assessed, as it is possible that morphological elements associated with word classes, such as the -*ado* past participle morpheme in Spanish, could create an effect. There did not appear to be any significant patterns of word class for this subset of data. This may indicate that word class does not motivate cross-language influences to be realized as the categorical and halfway influences.

Conversation Analysis

The next potential factor considered was interactional elements of the conversations. Conversation analysis was conducted on the conversation surrounding the tokens with categorical and halfway influences. No conversational patterns were discovered in this analysis, meaning the linguistic and social elements of the interaction do not seem to be affecting which tokens receive categorical or halfway influence.

Other Potential Factors

Other factors, which were not incorporated in this study, could have caused these particular tokens to undergo the categorical or halfway influences. These factors include usage patterns, prosody, and lexical characteristics (e.g., cognate status). Simonet notes that "a thorough understanding of the phonetics and phonology of bilingualism needs to incorporate an understanding of the structure of the bilingual lexicon" as the connections between the lexicons of a bilinguals' two languages, such as cognates, have been shown to influence phonetic realizations in various ways (2016, p. 4). For example, Brown (2015) found that cognate status and usage patterns, with respect to the frequency in a favorable context variable, affect variations of word-initial /d/ reduction in Spanish-English bilingual speech. It is possible that these factors motivated the categorical and halfway influences; further analysis is needed to determine possible interactions.

Conclusion

It is also possible that the motivation for particular tokens to undergo categorical or halfway influences was not contingent on any particular factor and instead was random. It is currently impossible to conclude whether any of the above factors are motivators or whether there even are any motivators for this. Further research needs to be done to elucidate the occurrence of these influences.

Regardless, the presence of tokens with a categorical influence, as well as tokens with a halfway influence, offers two insights. First, phonological processes can be transferred cross-linguistically, where one language's process fully applies in the other is possible. Second, as I as previously mentioned, the rarity of tokens with categorical or halfway influence suggests that the gradient influences found were indeed gradient, low-level phonetic changes to the durations and amplitudes (and thus degrees of tapping and spirantization). This indicates that cross-language influence from a phonological process, or the lack thereof, occurs as both a low-level phonetic influence and a categorical phonological influence.

4.3 DELETED /d/S

Intervocalic Spanish /d/s realized as ∅ were not included in analyses due to the inability to measure them in Praat. However, these tokens are still crucial, because they clearly indicate a Spanish-like realization rather than an English-like realization, as ∅ is a standard realization of intervocalic Spanish /d/, while an intervocalic English /d/ would canonically be realized as [d]. In fact, rather than a direct deletion of the /d/ (i.e., /d/ → ∅) in Spanish, it is likely that the ∅ is the result of an augmentation of the lenition from spirantization (i.e., /d/ → [ð] → ∅). Thus, if the ∅ is in fact linked to spirantization, it would be even more evident why these tokens should have been included with the rest of "spirants". These tokens still could have been subject to cross-language influence from the lack of spirantization in English, and it is worth noting that we do not see any categorical deleted intervocalic /d/s in English. Therefore, analyses might have been more accurate had they included these "deleted" /d/ tokens.

4.4 GENERAL DISCUSSION

Recall that the goal of the current study was to examine whether phonological processes are cross-linguistically transferred – either promoted or inhibited – in code-switching contexts and whether code switches impact these influences.

VARIABLES

This study incorporated into the analyses the variables of distance from a code switch, direction in relation to a code switch, sentence level of a code switch, position in a word, and dominance of a language within a conversation. Past studies on the phonetics and phonology of code-switching have not yet investigated some of these variables nor potential effects of interactions between distance and these variables. Significant effects for the variables of distance, direction, and sentence level would indicate that code switches do indeed impact the cross-language influences, as these variables are inherently based upon the code-switching context, as opposed to monolingual or other bilingual speech contexts for bilinguals.

Distance

Effects of distance only occurred in 20% of the found interactions for gradient effects (and an even smaller percentage of the total number of *possible* interactions), indicating that distance is not a dominant driving force for *partial* applications of cross-language process transfers. However, as previously discussed, the categorical effects did appear to be partially motivated by distance from the code switch. This raises the question, then, of why distance from the code switch is a significant motivator of categorical effects but not gradient effects. If the categorical influences are just substantially stronger applications of the transferred process than gradient influences, it would make sense that the stronger applications would be closer to the code switch – even if we do not see that gradation within the gradient influence. It is also possible that this relates to the different systems of contrast between the languages in the current study, which will be further discussed later in this section. As we know, the phone in a token with a gradient effect is still identifiable as that original allophone, which would be less likely to create conflict in that language. However, the phone in a token with a categorical effect is identifiable as a distinct allophone that is a separate phoneme in that language, which could potentially create conflict such as phonemic and/or lexical confusion. Thus, to prevent this confusion, it would be crucial for those categorical tokens to occur near the code switch, as the close proximity to the other language could reduce the likelihood of phonemic and/or lexical confusion.

Direction

When direction affected cross-language influences, the hypothesized influences were found in perseverative tokens for gradient influences and nearly all categorical and halfway influences. This indicates that the speakers were more likely to make cross-linguistic connections as a residual effect of a code switch. This adds to the literature offering insight into the mechanisms of code-switching, which has found mixed results regarding a token’s direction in relation to a code switch.

Sentence Level

As previously mentioned, sentence level has been widely overlooked in past studies on cross-language phonetic/phonological influence in code-switching, with most either only examining tokens from intrasentential code switches or examining both types without analyzing them for potential differences. In the current study, the hypothesized gradient and categorical influences occur in “spirants” in intrasentential code switches; however, there were also unexpected gradient influences in “spirants” in intersentential code switches, affected by the interaction with the language effect. As the literature tends to focus on intrasentential code switches, the current study's findings on intrasentential code switches may be more relevant than those on intersentential code switches, indicating that the effects found in intrasentential code switches are indeed motivated by the code switch in the predicted ways. Furthermore, the patterns of influence near intersentential code switches indicate that the sentence level may not provide limitations, but rather differences, for cross-language phonetic/phonological influence in code-switching. Further research on the effects of sentence level can elucidate the relationship between the phonological level and other grammatical levels of code-switching.

Position-in-word

A token's position in a word seemed to play a minor role approximately half of the time, as we saw effects for "taps" but no interpretable effects for "spirants". The purpose of accounting for position was to investigate the ways in which position-in-word might affect other variables and interactions to account for the fact that some positions might resist influence while others would accept it. For "taps", the cross-language influence appeared in the word-initial position much more than in other positions in the word. The position variable was only analyzed in a model with the language and distance variables, meaning that we do not know whether any interactions would have occurred between position and any of the other variables (direction, sentence level, dominance of a language in a conversation). This means that models that did not include the position variable did not account for whether the durations and amplitudes of the word-medial and word-final positions obscured the effects of the word-initial position; thus, it is possible that the models for the other variables that did not show any effects/interactions might have if they had included position (to isolate the word-initial tokens, where the cross-language influence occurred). Additionally, the other models that did find effects might have been more accurate had they included position.

Dominance of a Language in a Conversation

Findings indicate that both languages are influenced approximately equally, meaning that both languages also exert an approximately equal force. To get a better understanding of the effects of language, the gradient effects were analyzed with respect to the degree of dominance of one language in the conversation. The results showed that “tap” durations did not show any significant effects, while the results for “tap” amplitude and “spirant” amplitude did not show any logical, explainable patterns that would indicate any effect of dominant language on the degree of cross-language influence. This suggests that the degree of English dominance of conversation, or more generally the dominant language in a conversation, does not affect the cross-language phonetic/phonological influences in code-switching.

It is worth noting that the calculated degree of dominance for the conversation with the redacted speaker may have been unreliable because the calculations represented only one speaker, rather than the whole conversation. If the degree of dominance for this conversation was significantly inaccurate, it might have negatively influenced results.

Conclusion

This section primarily covered gradient influences because, as previously mentioned, conclusions cannot be made regarding potential effects of these variables for categorical influences, with the exception of distance, due to the lack of any significant patterns, which is potentially greatly due to the small number of categorical influences available for analysis. Even so, the fact that the variables of distance, direction, and sentence level inherently apply specifically to code-switching contexts and were each shown to affect either the gradient or categorical influences suggests that the code switch in these contexts did indeed affect the effects found. It is unclear why sentence level applies to spirants but not taps, and why direction and position apply to taps but not spirants.

SYSTEMS OF PHONEMIC CONTRAST

As previously mentioned, the phonological processes examined in this study were selected for their resulting allophones' phonemic contrast in the opposite languages to investigate possible effects of these systems of contrast on our findings. The equal degree of influence exerted and received by both languages indicates that not only did neither language's phonological system nor general presence exerts greater control, but also that neither language's system of contrast exerted greater control. The fact that neither system of contrast exerted more influence further corresponds with the conclusion that the dominant language in a conversation does not affect the patterns of influence, because if it did, then there would be an asymmetry in which system of contrast was more influential than the other. It is, however, possible that both systems of contrast did exert influence: they may have limited the promotion effects and caused the inhibiting effects.

For the promotion effects (again, predicted in hypotheses 1 and 2), it is possible that these influences would be stronger for other phonological processes, whose resulting allophones are not contrastive phonemes in the opposite language. In the current study, it is possible that the phonemic contrast of [ɾ] in Spanish prevented Spanish from accepting too much influence from the promotion of the tapping process to prevent Spanish /t/s from becoming *too* tap-like [t]s or even [ɾ]s, and that the phonemic contrast of [ð] in English prevented English from accepting too much influence from the promotion of the spirantization process to prevent English /d/s from becoming *too* spirant-like [d]s or even [ð]s. This is because there would then be the usual phonemic [ɾ] as well as the as the allophonic [ɾ] and tap-like sounds in Spanish, and there would be the usual phonemic [ð] as well as the allophonic [ð] and eth-like sounds in English, which could cause perceptual difficulty for both the speaker and listener, leading to phonemic and/or lexical confusion. Therefore, other phonological processes might have a stronger degree of gradient influence and a higher frequency of tokens with categorical influence from the cross-linguistic promotion of a process. And, as previously discussed, distance from the code switch may have less of an effect, as there would be less need to be closer to the other language.

For the inhibition effects (predicted in hypotheses 3 and 4), it is possible that the phonemic contrasts in one language contributed to the cross-language inhibition of a particular process in the other language – either instead of or in addition to the lack of that process in the other language – to prevent the allophone with phonemic contrast in the other language from appearing too close to that language in order to prevent phonemic and/or lexical confusion in either language. The phonemic contrast of [ɾ] in Spanish may have prevented the speaker from fully applying the tapping process to some intervocalic Spanish /t/s in tapping contexts (which would canonically be produced as [ɾ]), causing them to instead be produced as [t], or at least more stop-like than usual. The phonemic contrast of [ð] in English may have prevented the speakers from applying the spirantization process fully to intervocalic English /d/s, causing them to be produced as [d], or at least more stop-like than usual. Therefore, if the systems of contrast are indeed playing a role in the cross-language process inhibition, then other phonological processes in this context might have a weaker degree of gradient influence and a lower frequency of tokens with categorical influence from the cross-linguistic inhibition of a process, or possibly even no gradient or categorical inhibiting effects. While some past studies indicate that phonological process inhibition is possible for bilinguals – in and outside of code-switching contexts – other studies did not find it to occur; thus, it is not possible to know whether it would have occurred in this particular context without the phonemic contrast element.

In sum, the systems of contrast may be limiting promotion effects to prevent conflict within one language, and they may be causing inhibition effects to prevent conflict between the sections of each language that are in close proximity to each other. Overall, there is no definitive indication of whether systems of contrast may be playing a role in these cross-language influences; however, there is reason to believe that it may be possible. Similar research needs to be conducted on other phonological processes to serve as a comparison to elucidate the role of systems of contrast in cross-language phonological influence. For example, a future study could examine the Spanish spirantization process of /g/ → [ɣ] and the English tapping process of /nt/ → [ɾ̃] under similar conditions, as these processes' resulting allophones do not have phonemic contrast in the other language. These findings would contribute to our understanding of the role of systems of contrast in interactions between bilinguals' two phonological systems as well as how the proximity of their two languages in a single speech context could affect that.

GRADIENT INFLUENCE VERSUS CATEGORICAL INFLUENCE

Further, although this study finds that process transfer can be realized categorically, the small number of categorical influences, relative to the significance of the gradient influences, suggests that speakers prefer to avoid applying a process to the extent of a categorically distinct realization. This may suggest that interaction between a bilingual's phonological systems is limited, as distinction between these systems is maintained. For the current study, this may also suggest an underlying desire to avoid producing the resulting allophone due to its phonemic status in that language in order to prevent phonemic or lexical confusion.

PROMOTION VERSUS INHIBITION

The presence of both promotion effects and inhibition effects may suggest that a speaker's underlying desire to reduce markedness and desire to preserve the underlying form are competing in the interaction between bilinguals' phonologies, at least in code-switching contexts. The presence of the promotion of phonological processes could indicate that languages *want* to adopt phonological processes because processes generally reduce markedness (i.e., improve ease of articulation); thus, a language would either catalyze or just not resist cross-language process promotion. Inhibition of a process could indicate that languages want to preserve their underlying forms; thus, a language would either catalyze or just not resist cross-language process inhibition. However, the desire to avoid markedness would likely prevent processes from being inhibited, as languages would want to maintain their processes and therefore resist cross-language influence, and the desire to maintain the underlying forms would likely prevent processes from being promoted.

In the current study, both promotion and inhibition occur through gradient effects, and only promotion occurs through categorical effects. Thus, in the current study, for the gradient effects, we can conclude that neither desire is exerting more control; for the categorical effects, it is possible that the desire to avoid markedness is exerting more control, but due to the small number of categorical tokens, it is impossible to determine if this is the case. Although the current study found significant effects for both promotion and inhibition, the majority of past studies only found one of the two types of effects. While other factors, such as sequence of bilingualism (L1 versus L2) sometimes appeared to be the reason for this, some of the findings do not have any clear cause for this, meaning that the competition between the desire to avoid markedness and the desire to maintain the underlying form may have been playing a role in those results.

FURTHER RESEARCH

As previously mentioned, further research is needed to determine the potential role of the systems of contrast on cross-language influences and on the interaction between a bilingual's two phonological systems more generally. Moreover, future work can investigate whether one speaker's phonetic realizations in one language can be influenced by the other language when spoken by the other speaker in the preceding turn (i.e., cross-linguistic influence in cross-speaker code-switching). Lastly, future work can incorporate social factors, such as language attitude, which has been shown to affect phonetic convergence between speakers and could potentially affect convergence, or interactions, between a bilingual's phonological systems.

5. CONCLUSION

The current study explores the interaction between adult bilinguals' two phonological systems by investigating the effects of code-switching on the cross-language transfer of phonological processes. Prior research has suggested that bilinguals have connections between phonological systems, including both inhibition through gradient effects (partial applications) and promotion through categorical effects (full applications). Prior research on code-switching suggests that code-switching contexts can strengthen cross-language phonetic convergence of VOT and vowel quality, meaning code-switching can strengthen cross-language interactions between phonetic systems. Few studies have examined whether code-switching can influence cross-language interactions between *phonological* systems. Some of those studies found that phonological process transfer can occur in code-switching contexts, while others did not find any evidence of it. The current study expands on this by asking whether the phonological processes of Spanish spirantization and English tapping are cross-linguistically promoted or inhibited by another language in code-switching contexts and whether code switches affect the degree and/or frequency of these cross-language influences.

In this study, three main hypotheses were tested. The first main hypothesis predicted that phonological processes of one language would transfer into the other language across a code switch. Specifically, near the code switch, the English tapping process would influence Spanish /t/s, and the Spanish spirantization process would influence English /d/s. The second main hypothesis predicted that the lack of a particular phonological processes in one language would inhibit that process in the other language across a code switch. Specifically, near the code switch, Spanish’s lack of /t/ tapping would inhibit that process in English, and English’s lack of /d/ spirantization would inhibit that process in Spanish. The third main hypothesis predicted that the cross-language influences would be stronger closer to a code switch.

Findings indicate that both phonological processes are significantly promoted and inhibited across languages in code-switching contexts, supporting the first two main hypotheses. Although effects of both promotion and inhibition occur, promoting effects appear to be more frequent than inhibiting effects, which can offer insight into the motivations behind cross-language transfers. Further, the code-switch motivated cross-language effects of inhibition occur through phonetically gradient effects on degrees of tapping and spirantization, and the effects of promotion occur through both gradient and categorical effects. In sum, a phonological process or lack thereof can exert influence (i.e., a process can be promoted or inhibited) across languages in a code switch — usually only partially, with phonetically gradient effects, but occasionally to the extent of a categorical allophonic shift. The small number of categorical influences, relative to the significance of the gradient influences, suggests that speakers prefer to avoid applying a process to the extent of a categorically distinct realization.

Distance from the code switch appears to have significant impacts for categorical effects but not gradient effects, which offers some support for the third main hypothesis. However, the direction in relation to the code switch and the sentence level of the code switch appear to have some significant impacts for gradient effects but not categorical effects. Due to these three variables' inherent connection to code-switching, together, the occurrence of patterns in relation to these variables indicates that a code switch can affect the degree/frequency of cross-language phonological process transfer. Moreover, the dominant language of a conversation did not appear to affect the cross-language phonological interactions, adding to the literature on the effects of dominant language and of larger speech contexts on bilinguals' cross-language phonological interactions. The systems of phonemic contrast may be playing a role in these cross-language interactions, but further research is needed to determine this; thus, this study's findings lay the foundation for further discoveries on the interactions between bilinguals' two phonological systems with respect to their systems of phonemic contrast (in general and in regard to languages' proximity in a speech context).

While some past studies on phonological process transfer in code-switching found no effects, other studies and the current study demonstrate that code-switching can indeed affect the cross-language transfer of phonological processes. This means that the code-switching context and potentially other bilingual speech contexts can strengthen interactions between bilinguals' phonological systems, in addition to their interactions between phonetic categories. This study also expands the range of phonological processes known to transfer in and have transfers influenced by code switching, and it demonstrates that a given code-switching context can strengthen influences from both languages simultaneously. Thus, the finding that code-switching can support and strengthen phonological process transfer contributes to our understanding of the boundaries of phonological systems. It also shows that code-switching can impact the ways in which bilinguals challenge those boundaries and, thus, the boundaries of languages' grammars.

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APPENDIX A: CONVERSATION TRANSCRIPTS

Maria 1: http://bangortalk.org.uk/pdfs/miami/maria1.pdf

Sastre 4: http://bangortalk.org.uk/pdfs/miami/sastre4.pdf

Sastre 9: http://bangortalk.org.uk/pdfs/miami/sastre9.pdf

APPENDIX B: DELETED SPANISH /d/ TOKEN WORD CONTEXTS

The bolded letters indicate the sounds collected as tokens. For larger context, see the corresponding transcripts linked above.

Maria 1

1. Na**d**ie – line 24
2. Parte **d**el – line 71
3. Le **d**igo – line 185
4. Te **d**ice – line 219
5. Acondiciona**d**o – line 261
6. Déjame **d**ecirte – line 282

Sastre 4

7. Da**d**o – line 362
8. Demasia**d**o – line 472
9. A decir – line 488
10. Puedes – line 631
11. She **d**oesn't – line 688
12. Pue**d**e – line 689
13. Puede – line 716
14. Avanza**d**o – line 738
15. To**d**o – line 913
16. Para **d**ecirle – line 1099
17. Me **d**ijo – line 1105

Sastre 9

18. Pue**d**e – line 9
19. Que**d**ar – line 9
20. Pue**d**es – line 121
21. To**d**o – line 137
22. Na**d**a – line 235
23. Me **d**a – line 249
24. To**d**o – line 274
25. Cansa**d**o – line 297
26. To**d**o – line 329
27. Pue**d**e – line 357
28. To**d**o – line 551
29. Pue**d**e – line 637
30. To**d**o – line 651
31. Entra**d**o – line 745
32. To**d**os – line 753
33. Ayu**d**a – line 755
34. Mie**d**o – line 755
35. Mie**d**o – line 755
36. Miedo **d**e – line 755
37. To**d**o – line 755
38. Quiero **d**ecir – line 904
39. Me **d**ice – line 936
40. To**d**o – line 1034
41. Te **d**igo – line 1077
42. Le **d**ije – line 1146
43. Yo **d**ejé – line 1186
44. Dejé **d**e – line 1186
45. Pue**d**e – line 1367
46. Na**d**a – line 1414

APPENDIX C: AUDIO FILE EXCERPTS OF CATEGORICAL AND HALFWAY INFLUENCE EXAMPLES

The audio files below correspond to the examples provided above in the results section.

- Categorical Influence Example #1: Tapping Promotion
  - Audio File • Hyperlink
  - Line 425 in Sastre 9 transcript

- Categorical Influence Example #2: Spirantization Promotion
  - Audio File • Hyperlink
  - Line 896 in Sastre 9 transcript

- Halfway Influence Example #1: Tapping Promotion
  - Audio File • Hyperlink
  - Line 1000 in Sastre 4 transcript

- Halfway Influence Example #2: Spirantization Promotion
  - Audio File • Hyperlink
  - Line 186 in Maria 1 transcript

- Halfway Influence Example #3: Tapping Inhibition
  - Audio File • Hyperlink
  - Line 232 in Sastre 9 transcript