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Bilingual phonological interaction: Cross-language process transfer in code-switching

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Abstract. Bilinguals challenge the boundaries of languages' distinct grammars – including their phonological systems and phonological processes – but the impact of code-switching on the challenging of these boundaries is not fully understood. 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. 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? To answer these questions, I examine the /t/ → [ɾ] tapping process of English and /d/ → [ð] spirantization process of Spanish. Data was collected from the Miami Corpus (Bangor University). Results indicate that phonological processes and the lack of particular processes can transfer cross-linguistically in code-switching contexts, and these transfers can be realized through phonetically gradient and, occasionally, categorical effects. Results also indicate that code switches can indeed affect the nature of these cross-language phonological processes transfers. These results suggest that code-switching can motivate the interaction between a bilingual's two phonological systems and offer insight into the nature of phonological systems' boundaries.

Keywords. code-switching; bilingualism; phonology; phonological systems; phonological processes; cross-language influence; transfer

1. Introduction and methods. This 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.

1.1. LITERATURE REVIEW. Past studies have investigated the interactions between bilinguals' phonetic systems and the interactions between their phonological systems. Findings have shown that bilinguals have plastic connections between phonetic categories in their two languages (Simonet 2016). These phonetic categories include voice onset time and vowel quality (e.g., Sancier & Fowler 1997; Simonet 2014; Flege 1987). Findings have also shown that phonological processes from a speaker's native language can be partially applied in their second language (Simon, 2010) and that the lack of a process in one language can somewhat inhibit that process in the speaker's other language in bilingual contexts (Simonet & Amengual 2020).

Bilingual speakers sometimes make use of both languages/phonological systems in interaction; this process is called code-switching. Many studies have looked at effects of code-switching on sound realizations through phonetics measures and have found cross-linguistic influences on voice onset time, vowel quality, and vowel duration, wherein one or both languages influence the other by causing within-speaker convergence between languages (e.g.,

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Bullock et al. 2006; Elias, McKinnon & Milla-Muñoz 2017). Thus, code-switching can influence interactions between phonetic systems.

However, few studies have investigated the potential effects of code-switching on phonological system interactions, especially on phonological processes. Of those few, studies on voiced stop spirantization have had mixed results (Brown, 2015; Piccinini, 2016; Henriksen et al., 2021), and one study found that /l/ velarization in English and Spanish influenced each other (Piccinini, 2016). And Olson (2019) found that phonological processes can occur across code-switch points, with the context in one language and the effect in the other.

1.2. PURPOSE AND RESEARCH QUESTIONS. The current study aims to elucidate the relationship between a bilingual's two phonological systems by examining the relationship between code-switches and cross-language phonological interaction. To this end, this study asks two main questions:

1. Can a bilingual speaker cross-linguistically transfer phonological processes (promotion) and/or the lack of particular processes (inhibition) in code-switching contexts?
    a. And are phonological processes more likely to be promoted or inhibited cross-linguistically?
2. Do the properties of a code switch affect the degree of influence of these cross-linguistic process transfers?
   This question is investigated through three sub-questions:
    a. Does a token's distance from a code switch affect the degree of influence it receives?
    b. Are tokens influenced more before or after a code switch?
    c. Are tokens in intrasentential code switches or intersentential code switches influenced more?

1.3. CURRENT STUDY. To investigate these questions, I examined Spanish-English code-switching contexts. The current study analyzes intervocalic cases of the /d/ → [ð] spirantization process of Spanish, in which the voiced stop /d/ undergoes lenition and is realized as the voiced fricative [ð]; this study also analyzes intervocalic cases of the /t/ → [ɾ] tapping process of English in which the voiceless stop /t/ is realized as the voiced [ɾ] in intervocalic contexts in which the following vowel is unstressed. Note that the canonical resulting allophones of these processes are phonemic in the other language: [ɾ] is an allophone of English but a phoneme of Spanish, while [ð] is an allophone of Spanish but a phoneme of English.

1.4. HYPOTHESES. The hypotheses for this study are illustrated in Figure 1 below. This includes an example sentence in which the red letters are the tokens of interest for analysis. The first hypothesis is that phonological processes will be promoted cross-linguistically, meaning they will be applied in the other language, in which it is not part of the grammar. Tapping, from English, will be applied in Spanish, which will cause the degree of tapping in Spanish /t/s to increase, as shown on the bottom left of the diagram. In the same manner, spirantization, from Spanish, will be applied in English, as shown on the bottom right.

The second hypothesis is that phonological processes will be inhibited cross-linguistically, meaning that the lack of a particular process in one language will inhibit the application of that process in the language in which it is part of the grammar. Tapping will be inhibited in English due to the lack of tapping in Spanish, which will cause the degree of tapping in English /t/s to decrease, as shown on the top right of the diagram. In the same manner, spirantization will be inhibited in Spanish, due to the lack of spirantization in English, as shown on the top left.

The last hypothesis is that the influences of transferred processes will be stronger closer to the code switch. In other words, the degree of influence will decrease as distance from the switch increases.

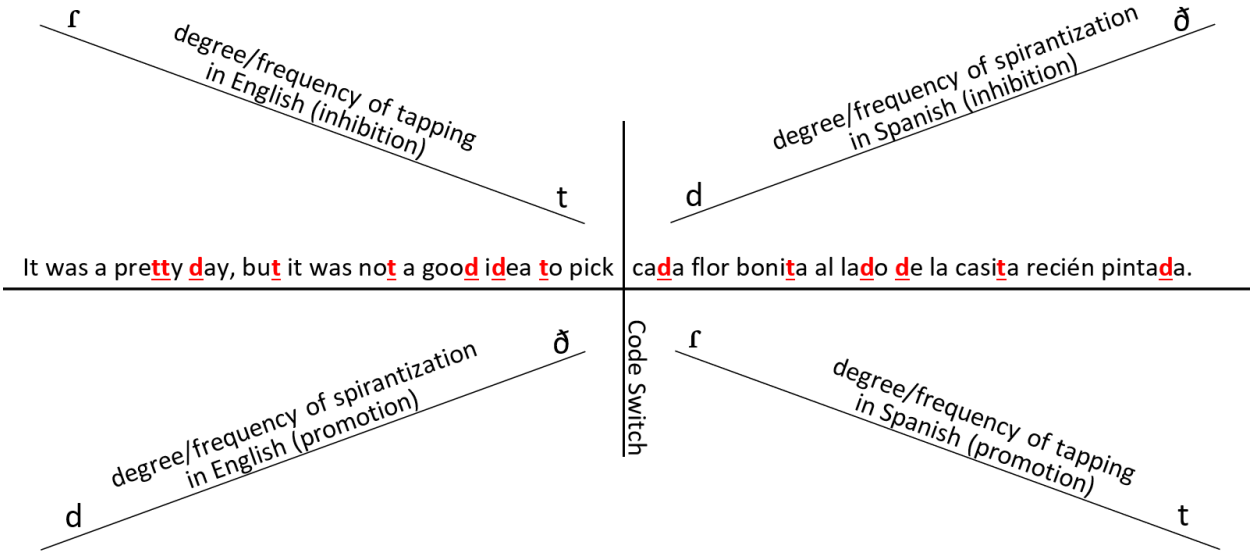

Figure 1. Hypotheses

1.5. METHODS. Data was collected from Spanish-English code-switching contexts in spontaneous speech from five female bilinguals in Miami, which came from the Miami Corpus (Bangor University). Tokens were collected from turns containing a code switch, and sounds from loan words were not included. Tokens were collected through Praat and were measured phonetically to determine a degree of influence.

1.5.1. GRADIENT EFFECTS OF TRANSFER. To assess the transfer of tapping – the process from English – this study examines if Spanish /t/ becomes slightly more tap-like and if English /t/ becomes slightly less tap-like. This was done by looking at tokens in tapping contexts, which were intervocalic English and Spanish /t/s followed by an unstressed vowel. They are canonically realized as [ɾ] in English (e.g., the /t/ in "go to") and [t] Spanish (the /t/ in "a tener"). To analyze these tokens, the degree of tapping was measured in duration (in seconds) and amplitude (in dB, standard score), as these measures generally differ between these sounds. [ɾ] is expected to be shorter than [t], as taps are inherently short. And [ɾ] is expected to be louder than [t], because [ɾ] is voiced, while [t] is a voiceless stop. 118 of these tokens were collected (70 in English, 48 in Spanish).

To assess the transfer of spirantization – the process from Spanish – this study examines if English /d/ becomes slightly more eth-like and if Spanish /d/ becomes slightly less eth-like. This was done by looking at tokens in spirantization contexts, which were intervocalic Spanish and English /d/s. They are canonically realized as [ð] in Spanish (e.g., the /d/ in "nada") and either [d] or [ɾ] in English (e.g., the /d/ in "today" as [d]; the /d/ in "wedding" as [ɾ])[1]. To analyze these tokens, the degree of spirantization was measured in amplitude (in dB, standard score), as [ð] is

[1] Both allophones of English /d/ ([d] and [ɾ]) were included with spirantization context tokens because the focus is to determine whether the /d/ spirantization process of Spanish is being applied to the *underlying* representation, as it would be in Spanish.

expected to have a higher amplitude than [d], because [ð] is a fricative, while [d] is a voiced stop. 228 of these tokens were collected (105 in English, 123 in Spanish).

The duration and amplitude of each token were retrieved via script in Praat, and the results were explored using a linear mixed effects model. The following independent variables were analyzed:

- The token's distance from a code switch (measured in syllables)
- The token's direction in relation to a code switch (before or after a code switch)
- The sentence level of the code switch in which the token occurs (intersentential or intrasentential)
- The token's position-in-word (word-initial, word-medial, or word-final)

Position-in-word was included because of the possibility that some positions would be resistant to any change. This variable would prevent any resistant positions from skewing results, and it allows us to isolate the positions that are influenced to see what changes occur.

2. Findings. Below are the results for each dependent variable: tapping context duration, tapping context amplitude, and spirantization context amplitude.

2.1. TAPPING CONTEXT: DURATION. As previously noted, token duration was used to help indicate the degree of tapping. Taps are shorter than stops, so if tapping occurs here, we would expect a shorter duration. As shown in Figures 2 and 3, the findings indicate that my expectations were accurate. We see that the Spanish tokens in tapping contexts were shorter, or more tap-like, and English tokens were longer, or less tap-like, when they occurred after a code switch (est.= -3.479e-02, t= -2.572, p= 0.012) and when they occurred in word-initial position (est.= -3.838e-02, t= -1.823, p= 0.071).

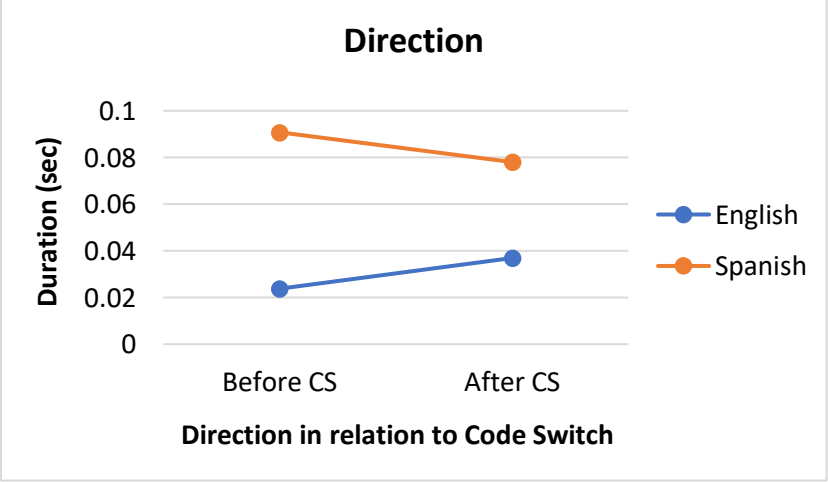

Figure 2. Average tapping context token duration by language and direction

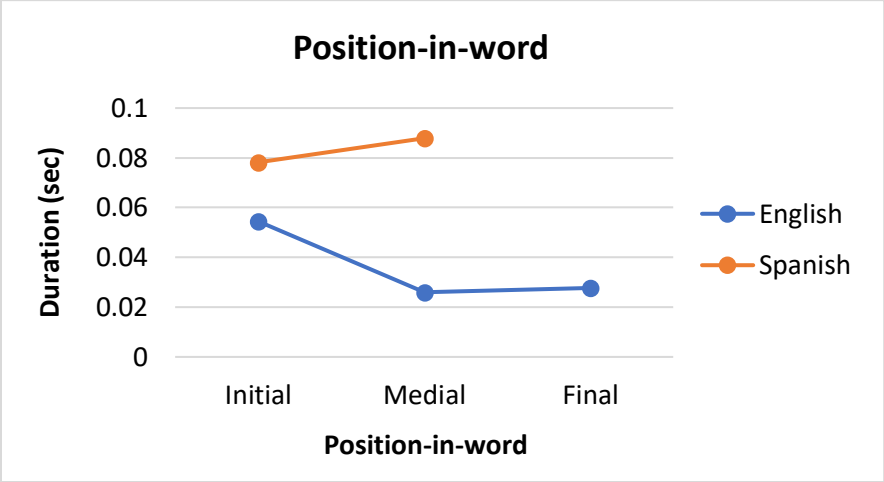

Figure 3. Average tapping context token duration by language and position-in-word

2.2. TAPPING CONTEXT: AMPLITUDE. Token amplitude was also used to help indicate the degree of tapping. Taps are louder than stops, so if tapping occurs here, we would expect a higher amplitude. As shown in Figures 4 and 5, the findings indicate my expectations were again accurate. The Spanish tokens in tapping contexts were louder, or more tap-like, and English tokens were quieter, or less tap-like, when they occurred after a code switch (est.= 1.26683, t= 2.303, p= 0.023) and when they occurred in word-initial position (est.= 1.322253, t= 1.669, p= 0.098). These are the inverse of the tapping duration effects, supporting the interpretation that this means the sounds are becoming more/less tap-like, not just changing duration and amplitude due to other causes. Standard score was used to account for significant variation in volume between speakers.

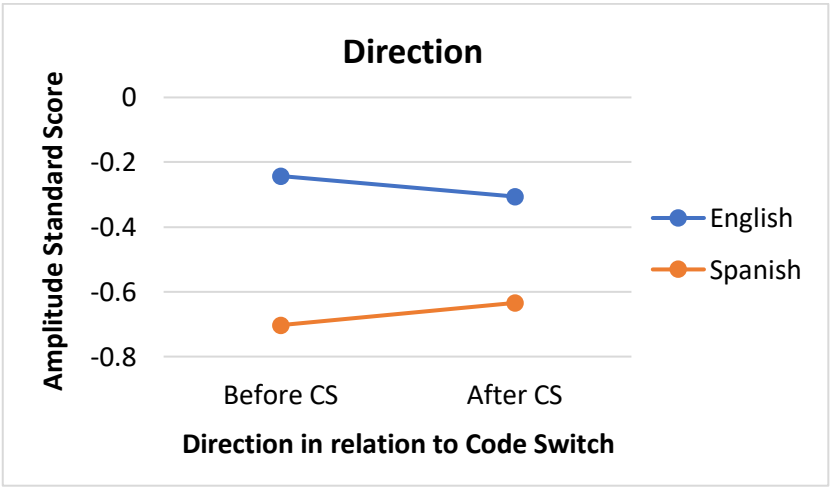

Figure 4. Average tapping context token amplitude by language and direction

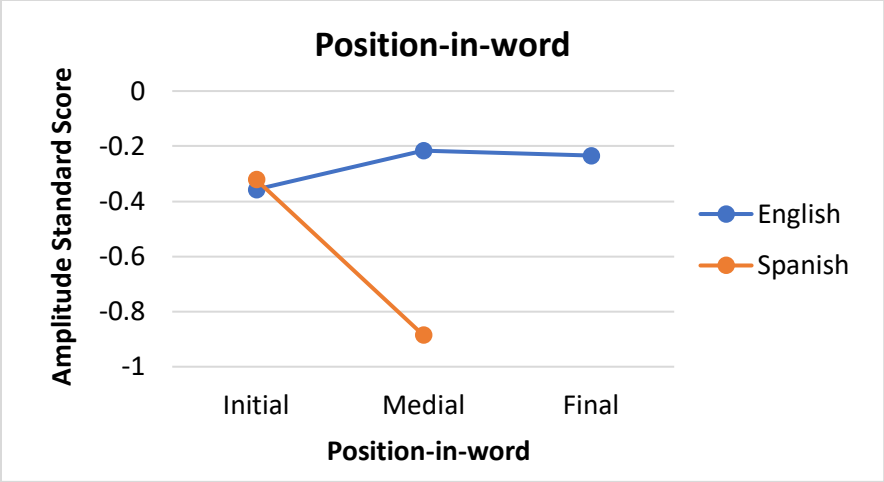

Figure 5. Average tapping context token amplitude by language and position-in-word

2.3. SPIRANTIZATION CONTEXT: AMPLITUDE. As mentioned, the current study also looks at spirantization contexts, where we expect voiced stops to become fricatives. Token amplitude was used to help indicate the degree of spirantization. Fricatives are louder than stops, so if spirantization occurs here, we would expect a higher amplitude, which we see is the case in Figure 6 below. Spirantization was affected by different variables from those that affected tapping: direction and position-in-word were not significant here, but the token's distance from the code switch and whether the code switch was intersentential or intrasentential did have effects. Here we see that in intersentential tokens farther from a code switch the English tokens in spirantization contexts were louder, or more eth-like, and Spanish tokens were quieter, or less eth-like (est.= 0.15008, t= 2.143, p= 0.034).

This suggests that there is more cross-language influence of process transfers in intersentential tokens farther from the switch, and the influence decreases closer to the switch. This is the most logical interpretation of the patterns in this figure because we can see that the intersentential and intrasentential /d/s of each language merge closest to the code switch, which indicates that closest to the code switch, the phone is at its canonical form, comparable to what might result in monolingual speech. This means that farther from the switch is where influence from the code switch occurs. Again, the expected influence of transfer would be for Spanish /d/s to get quieter, or less spirant-like, and for English /d/s to get louder, or more spirant-like; as this expected pattern of influence occurs in the intersentential tokens, we can conclude that those are the tokens that receive the effect of cross-language process transfers. So in sum, we can see that the influence of the cross-language phonological process transfer is strongest in tokens farther from the switch in intersentential code switches.

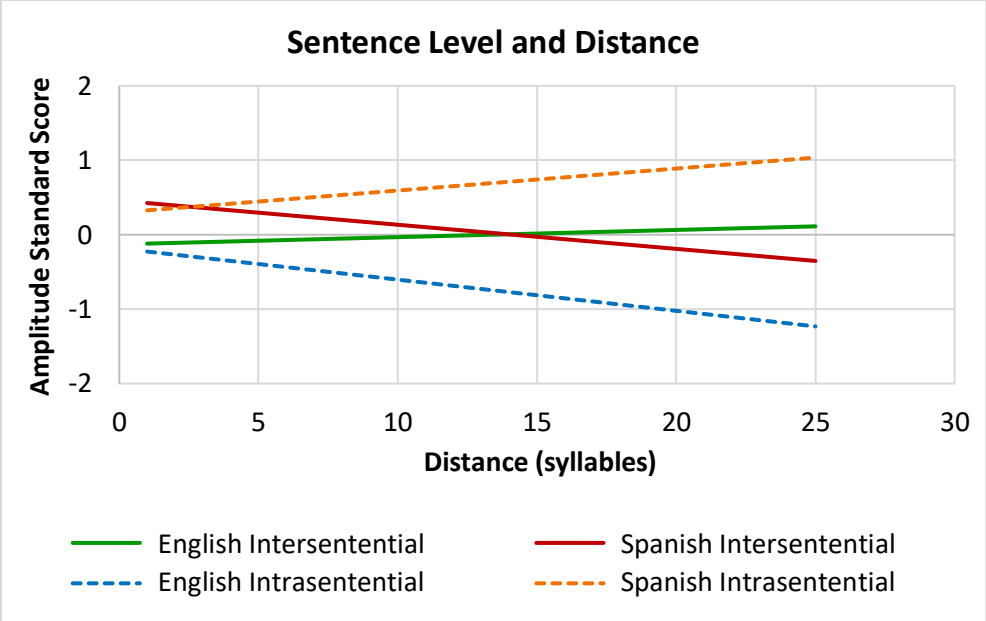

Figure 6. Average spirantization context token amplitude by language, distance, and sentence level

2.4. GRADIENT EFFECTS SUMMARY. In sum, effects were found in all 3 dependent measures: tapping context duration, tapping context amplitude, and spirantization context amplitude. In response to research question 1, promotion and inhibition influences were both found, and both languages appear to influence and be influenced equally. In response to research question 2, the independent variables of distance from the code switch, direction in relation to the code switch, and the sentence level of the code switch all affected the degree of influence.

For tapping context tokens, Spanish /t/s were more tap-like and English /t/s were less tap-like (in other words, transfer was stronger) in tokens after a code-switch and in word-initial tokens (i.e., independent effects of direction and position).

For spirantization context tokens, English /d/s were more eth-like and Spanish /d/s were less eth-like in tokens farther from the code switch in intersentential code switches (i.e., effects of the interaction between distance and sentence level).

2.5. CATEGORICAL EFFECTS OF TRANSFER. The aforementioned effects were gradient effects, which signify the partial application or inhibition of a transferred process, realized as effects on the degree of tapping or spirantization. However, there was also a small number of tokens that had a categorical effect, which signifies a fuller application or inhibition of a transferred process. In categorical effects, the token influenced by the phonological process transfer is realized as an identifiably different allophone – the allophone canonically expected for that process in the other language (e.g., Spanish /t/ realized as [ɾ]). Both gradient and categorical effects result from the application of transferred phonological processes, but categorical effects have a stronger effect, realized as a distinct allophone, whereas gradient effects have a more subtle effect, realized as the same initial allophone but with phonetic distinctions.

The spectrogram in Figure 7 below demonstrates an example of a categorical effect, where tapping applies in Spanish, which shows that English can promote the application of /t/ tapping into Spanish. The labelled segment is the intervocalic Spanish /t/ from "*a tener*," which is

realized as [ɾ], as indicated in the spectrogram by the gap in the dark third formant of the surrounding vowels.

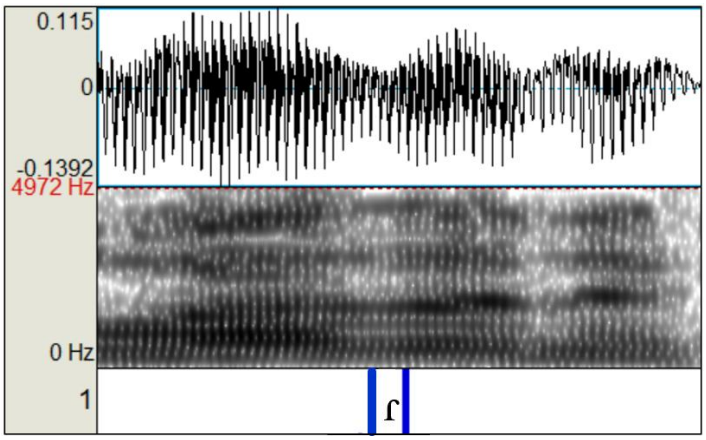

Figure 7. Categorical effect of tapping transfer

Here, the spectrogram in Figure 8 below shows an example of a categorical effect where spirantization applies in English, which shows that Spanish can promote the application of /d/ spirantization into English. The labelled segment is the intervocalic English /d/ from “today”, taken from the sentence “for example, you know like for instance today *ya yo tengo* rosetti”. The /d/ is realized as [ð], as indicated in the spectrogram by phonetic cues typical of spirants, rather than stops.

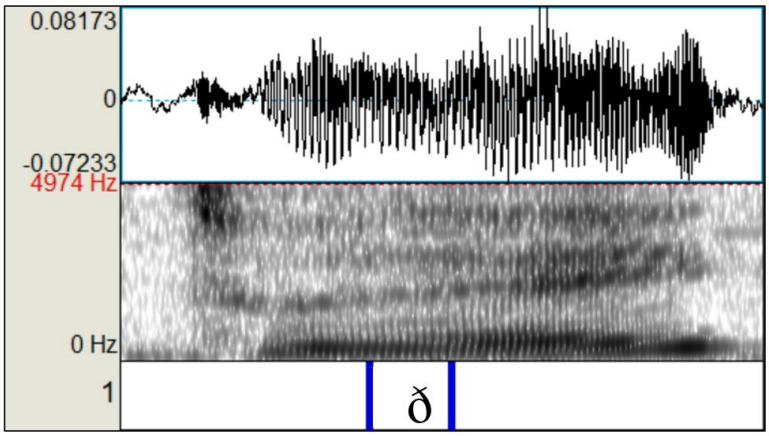

Figure 8. Categorical effect of spirantization transfer

Again, only a small number of tokens – approximately 1.5% of all collected tokens – had categorical effects. These effects occurred for both tapping and spirantization, but primarily occurred with promotion effects, not inhibition effects.

The categorical effects appear to be influenced by the token’s distance from a code switch. 80% of tokens with categorical promotion effects occurred within 3 syllables away from a code switch, suggesting that the close proximity of 1 to 3 syllables from a code switch is conducive to cross-language phonological influence. In comparison, for the full set of tokens, there is an approximately 30% likelihood that any given token would fall within three syllables from a code switch; thus, if this specific proximity were not a motivator for categorical effects, only approximately one third of the categorical tokens would have occurred within three syllables

from the switch. As the actual percentage of categorical tokens in this proximity range is far higher, we can conclude that there is indeed a correlation between distance and categorical effects.

Unlike the gradient effects, the categorical effects do not appear to correlate with the token's direction in relation to the code switch or whether it appears in an intersentential or intrasentential code switch. However, due to the small number of categorical tokens, there is not enough data to conclusively rule that out; more research needs to be done to further investigate this.

3. Summary and significance.

3.1. RESEARCH QUESTION 1 CONCLUSION. Research question 1 asked if a bilingual speaker can cross-linguistically transfer phonological processes (promotion) or the lack of particular processes (inhibition) in code-switching contexts.

Results indicate that cross-language phonological process transfer may occur in code-switching contexts, differing from some of the previous literature, but supporting my hypotheses. This means that the code-switching context can motivate interactions between bilinguals' phonological systems. Processes can be both promoted and inhibited cross-linguistically; however, promotion appears to be more frequent. The stronger frequency of promotion could suggest that the desire for a sound to be unmarked, or easier to articulate, is stronger than the desire to maintain the underlying phoneme in the surface form of the word.

Results also indicate that the transfer of processes across languages can lead to both gradient and categorical effects, meaning a process of lack thereof that is transferred into the other language can be applied in that language to the extent of motivating a phonetically distinct realization and, in some cases, can be applied to the greater extent of motivating a realization as a distinct allophone. However, gradient effects are significantly more frequent. Although this study finds that process transfer can also be realized categorically, the small number of categorical influences, relative to the significance of the gradient influences suggests that suggests that speakers prefer to avoid applying a process to the extent of a categorically distinct realization. This may suggest that phonological interaction is limited, as distinction between phonological systems is maintained. While bilinguals are willing to slightly challenge the boundaries between languages' grammars, there is a limit to how far they are willing to challenge them; however, they sometimes fall short of maintaining significant distinction. 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.

Additionally, the findings demonstrate that although the phenomenon studied here is phonological, its influence manifested primarily as gradient effects, thus this phonologically motivated effect would not be observable without being analyzed with phonetic measures.

3.2. RESEARCH QUESTION 2 CONCLUSION. Research question 2 asked if the properties of a code switch (distance, token before vs. after, intersentential vs. intrasentential) affect the degree of influence from these transfers.

Results indicated that the properties of a code switch do have effects on the influences of cross-language process transfer. Tokens that occur after code switches and tokens in intersentential code switches are influenced more. The fact that tokens after switches are more influenced indicates that it is harder for speakers to maintain distinction once the other language has occurred. The fact that intersentential tokens are more influenced could suggest that when

the sentences offer more distinct boundaries between languages, there is less need for maintaining stronger phonetic distinction, thus allowing for more cross-language influence.

Regarding distance from a code switch, gradient effects are stronger farther from the switch, while categorical effects are stronger closer to it. These results may offer significant information. The finding that gradient effects are more influenced farther from the code switch could possibly indicate that although gradient influence is acceptable far from the code switch, it is less acceptable close to a code switch, potentially due to the speaker working to maintain boundaries between each language when they are in extremely close proximity to each other. This is supported by the fact that these effects are only gradient, as this limited degree of influence indicates too that the speaker is working to maintain boundaries between languages by not permitting a stronger degree of influence. As for the finding that tokens in intersentential code switches are influenced, this could be because where there is a clear distinction between languages provided by syntactic boundaries, cross-language influence is permissible (compared to intrasentential code switches, where less syntactic distinction between languages could necessitate more phonetic distinction to maintain the boundaries between languages). In sum, it appears that speakers want to maintain sufficient boundaries between languages; they work to prevent substantial cross-language phonological interactions through limiting phonological process transfer influence, but in situations where there are already clear boundaries between the two languages, there is room to be influenced.

Inversely, we saw that the categorical effects demonstrated more influence closer to the code switch. Although this may sound contradictory to our distance-related gradient effect findings, they may not be. If it is the case that speakers do indeed work to maintain boundaries between languages, as seen with the gradient effects, we could speculate that categorical effects represent a lapse in the ability to maintain boundaries. This is supported by the fact that the speaker is not able to prevent the phonological process transfer from application to the point of being realized as a distinct phoneme – the canonical phoneme of the other language. This notion of a lapse in the ability to maintain boundaries would explain why categorical effects are predominantly seen closer to the switch: the close proximity to the code switch is what triggers the weakening of boundaries.

In sum, when speakers possess the ability to maintain boundaries, they do so by only allowing gradient influences of cross-language transfer and by resisting any significant influence close to the code switch. On the other hand, when speakers momentarily lapse in their ability to maintain boundaries, they are easily triggered in the close proximity to have influence, resulting in strong effects near the code switch, and they also more fully apply the other languages processes/lack thereof to the extent of producing a distinct allophone — the other language's canonically resulting allophone for that context.

In gradient effects, the speaker is limiting cross-language influence, explaining why the individual effects are minimal and why the speaker is maintaining more distinction when the languages are in closer proximity. In categorical effects, the speaker is not able to limit the influence, explaining why the individual effects are significant and why the close proximity of the languages causes more interaction.

3.3. SIGNIFICANCE. This study's novel approaches to the topic fill in some of the gaps of the previous literature. These include its analysis of a new phonological process (tapping), of a process from each language in a code switch, and of both phonetically gradient and phonemically categorical effects for the same phonological process. This study demonstrates that a given code-switching context can strengthen influences from both languages simultaneously.

Finally, 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) and the orientation of transfer (promotion versus inhibition).

In conclusion, in addition to phonetic interactions, investigated in previous literature, bilinguals have interactions between their phonological systems, including phonological processes. The code-switching context can support cross-language interactions, suggesting that a speaker's use of two languages in relative proximity causes the boundaries of a language's phonological grammar to be challenged.

The code switch itself is significant as well, as opposed to solely the general code-switching context, as it may lead to various patterns of transfer, such as strengthening cross-language influence in some cases but inhibiting it in others. The assessment of the characteristics of the code switch offers insight into the nature of phonological interactions in code-switching, the boundaries of phonological systems, and the effects of code-switching on the boundaries of languages' grammars. Overall, our assessment suggests that although cross-language influence occurs in code-switching, the speaker works to maintain a significant amount of distinction between the languages' boundaries, yet sometimes falls short.

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