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Investigating The Production And Perception Of Lexical Stress In English As A Second Language: A Cue-Weighting Approach

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by

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ABSTRACT

The Cue-Weighting Transfer Hypothesis states that (a) listeners weight acoustic cues according to how informative they are in signaling a lexical contrast in their L1, and (b) that listeners transfer their cue weightings from the L1 to the L2, using those cues that are important in the L1 to perceive lexical stress in the L2 (Tremblay et al., 2021). Most of the Spanish-English bilinguals in our region are highly proficient in both languages, but differ in their language dominance spectrums. That is, they can handle both languages with ease, but are usually more dominant in one of them. Because of the bilingual uniqueness of this region, the present study tests the Cue-Weighting Transfer Hypothesis from a language dominance perspective, as opposed to doing so from an L2 proficiency perspective, like previous cue-weighting research has done. We tested Spanish-dominant and English-dominant speakers from our region using a lexical stress perception task and a lexical stress production task to investigate if these participants show evidence of cue-weighting transfer from the dominant into the non-dominant language in the perception and production of lexical stress. Our results revealed various differences manifested as a result of language dominance effects, two of the most salient ones being that (i) English-dominant speakers use vowel reduction to a significantly higher degree than Spanish-dominant speakers, and that (ii) in the absence of vowel reduction use, Spanish-dominant speakers increase their reliance on other acoustic cues like duration and pitch instead when producing and perceiving lexical stress in English. Our results provide support for the Cue-Weighting Transfer Hypothesis. We suggest that the differences in cue weightings across languages can be modulated by language dominance, and not just by L2 proficiency, like previous research has shown. That is, cue-weighting differences can be observed in speakers who are highly proficient in both languages, but differ in their dominance continuum.

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CHAPTER 1 – INTRODUCTION

The field of Second Language Acquisition (SLA) has focused on understanding bilingualism and the components of the bilingual mind. Research in this field has consistently proven that bilinguals are not two monolinguals in one. They have a rather complex mind where their two languages represent two systems, but are not independent, as they have been shown to influence each other in a variety of ways (Flege, 1995; Flege & Bohn, 2021). While these cross-linguistic influence effects have been largely studied from a proficiency perspective, suggesting that proficiency in the target language influences how second language learners perceive and produce speech sounds in the L2, little is known about the effects of language dominance on phonology, and about how (and if) language dominance can influence the amount of transfer than happens from one language to the other one. Language dominance and proficiency are often correlated (and possibly mistaken as being the same thing), but understanding how they differ from one another is important. Proficiency relates to an individual's reading, writing, speaking, and listening abilities in a particular language, and does not depend on bilingualism to exist (Gertken et al., 2014). That is, an individual can be monolingual, and their proficiency in their language can still be measured. Language dominance, on the other hand, arises as a natural result of being bilingual (Gertken et al., 2014). It is a relative measure that compares a bilingual's use of one language, relative to their use of the other one. Thus, while proficiency does not depend on bilingualism, language dominance does and can in fact change across a bilingual's lifetime: A bilingual can be dominant in a language during childhood and become dominant in another one during adulthood. It is also important to note that language dominance, as described in Gertken et al. (2014) when citing Hamers and Blanc (2000), does not translate into high proficiency, only into a state of equilibrium. Thus, a bilingual may have balanced dominance in their two

languages and be highly proficient in both, and another bilingual may also have balanced dominance but have low proficiency in both of their languages.

The goal of the present study is to better understand bilingualism, and to explore if an effect of language dominance, rather than one of proficiency is observed in the weightings of acoustic cues. Specifically, we seek to investigate how these cues are hierarchically ranked across languages, and whether language transfer from the dominant into the non-dominant language (if any) is observed, which would show direct support for the Cue-Weighting Transfer Hypothesis (explained in detail in the literature review section). In order to investigate our question and examine this possible transfer of acoustic cues, we employ an analysis of lexical stress in English. This allows us to see if dominance modulates how stress is perceived and produced by different groups (Spanish-dominant vs. English-dominant speakers), indicating which cues are used to a lesser or higher degree in each of them.

The highly bilingual region of El Paso, Texas offers a very interesting environment where both languages are spoken continuously, and sometimes simultaneously as well. While previous studies have tested cross-linguistic differences of lexical stress (Cooper et al., (2002); Cutler et al., (2007); Qin et al., (2017); Kim & Tremblay (2021); Tremblay et al., (2021); Kim & Tremblay (2022)), these have focused on proficiency effects, and have tested second language learners of English whose proficiency level is not high enough to account for balanced bilingualism in their L1 and English. No study so far has tested the perception and production of lexical stress in a bilingual region where speakers are highly balanced bilinguals. Thus, while other studies have focused on L2 proficiency, the present study tests the Cue-weighting Transfer Hypothesis from a language dominance perspective, using perception and production of lexical stress to do so. Our study investigates whether or not language transfer is present, taking into consideration that the speakers tested here are

bilinguals with high levels of proficiency in both Spanish and English, but with different language dominance spectrums.

Before diving into the further contents of the study, it is important to address how lexical stress differs from other types of phonological emphases that happen at the phrase- or sentence-level. Phonological emphasis serves a wide range of functions across languages. For example, the following three sentences are composed of the exact same words but communicate different intentions depending on the word we decide to emphasize (in this case, the one written in capital letters): (i) *she NEVER said that,* (ii) *she never said THAT,* (iii) *SHE never said that.* These different emphases serve a pragmatic function—to highlight the emphasized information over their implied alternatives in the discourse. Despite this variation in intonation, *what* we are communicating does not change in this case. That is, the actual meaning of the words remains the same, regardless of whether or not we decide to emphasize them at the sentence level.

When we talk about lexical stress, however, we refer to instances in which the manipulation of phonological emphasis happens at the lexical level and does in fact change the meaning of a word. In lexical stress, what varies is where in a particular word (i.e., in which syllable) we place the most emphasis or stress. Unlike the previous three-sentence example, lexical stress can contrast meaning across two words, yielding a minimal pair that differs solely on where the emphasis is placed. This change of meaning can happen across different syntactic categories (e.g., *PREsent* (noun) vs. *preSENT* (verb)) but also within them (e.g., *DEsert* (noun) vs. *deSSERT* (noun)).

Because lexical stress can serve a contrastive function in English (and in several other languages), studying the acoustic correlates that aid in its perception and production is relevant. This relevance is of particular interest for the field of SLA and bilingualism, as languages often vary in the importance of specific acoustic cues in the identification of stress.

This yields different weightings of acoustic cues across languages, and differences in how stress is both perceived and realized cross-linguistically. Thus, this study is motivated by our interest in bilingualism and cross-linguistic differences, as well as by our willingness to positively impact the field of SLA, showing that languages behave differently in how they process lexical stress, and that language dominance can play a role into how these differences are manifested.

The following sections provide a detailed recount of our study. Chapter 2 contains a review of previous literature that has tested cue-weightings in different populations of bilinguals and poses our research question at the end. Then, because this study is composed of two experiments (a production and a perception experiment), these are discussed separately in Chapters 3 and 4, respectively, containing all pertaining information for each (i.e., method, results, discussion). Finally, the paper finishes by offering a general discussion and conclusion in Chapter 5, and an Appendix is included at the very end, containing a copy of the language background questionnaire assigned to our participants.

CHAPTER 2 – LITERATURE REVIEW

Lexical stress is considered a suprasegmental feature, since it is imposed at the syllable-level within a word. Studying bilinguals' perception of lexical stress in English is important since, for L2 learners of this language, learning to perceive and produce lexical stress can be particularly difficult, given the fact that stress can have both grammatical and contrastive functions in English (Ladefoged & Johnson, 2010). Two words can be differentiated by lexical stress alone, depending on which syllable is pronounced with greater emphasis. For example, stress variations in English can be used to distinguish one noun from another (*desert* (as in nature) vs. *dessert* (as in sweets)), but they can also work to distinguish between two different syntactic categories (e.g., a noun and a verb). Such is the case for words like *present*, which can be a noun (e.g., *I bought you a present*) if stressed on the first syllable *(PRE-sent)* or a verb (e.g., *I will present at the conference*) if it has lexical stress on the second syllable *(pre-SENT)*.

When perceiving lexical stress, listeners rely on a variety of acoustic cues: (i) vowel quality, (ii) duration, (iii) pitch (i.e. fundamental frequency [f0]), and (iv) intensity. Vowel quality (i) is measured through formants and describes, in terms of vowel frontness, height, and roundness, how a vowel is different from another one, and determines if the pronunciation of a vowel changes from a full to a reduced one in a particular context. English, for example, uses vowel reduction as its main and most informative stress marker (Tremblay et al., 2021), which manifests itself through the tendency for vowels to be reduced from their full form to a schwa ([ə]) when found in an unstressed context. Such is the case of words like the noun *present (PRE-sent)* ([ˈprɛzənt]), whose second syllable is unstressed and, consequently, its vowel is reduced and pronounced as a schwa.

Duration (ii) describes the length of a syllable and, consequently, the length of a vowel within this syllable. Duration is also a reliable acoustic correlate of lexical stress in

English, in part because it is redundant with vowel quality: unstressed vowels are reduced (e.g., [ə]) and shorter than non-reduced ones (e.g., [ɛ]) (Tremblay et al., 2021). In Spanish, stressed syllables also tend to be consistently longer than unstressed ones, making duration a cross-linguistic correlate of stress (Ortega-Llebaria & Prieto, 2011). Thus, together, these two acoustic cues represent the most relevant determinants of lexical stress.

Pitch (iii) is an auditory property that allows listeners to place a sound on a scale going from low to high (Ladefoged & Johnson, 2010). The pitch of a sound is equated to its fundamental frequency (f0) since it measures, in Hertz, the glottal pulse rate of the vocal folds. This means that when the fundamental frequency of a sound is high, it is perceived as having a higher pitch. Lastly, intensity (iv) is often correlated to the loudness of a vowel, as the increased activity required from the respiratory muscles when producing a stressed syllable (compared to an unstressed one) results in greater vowel volume or loudness being perceived by a listener.

Together, these four cues combine in speech perception to aid speakers in recognizing lexical stress. However, the way these cues are weighted across languages differs. This difference in weighting can be explained through the Cue-weighting Transfer Hypothesis, which states that (a) listeners weight acoustic cues according to how informative they are to listeners in signaling a lexical contrast in the L1, and (b) that listeners transfer their cue weightings from the L1 to the L2, using those cues that are important in the L1 to perceive lexical stress in the L2 (Tremblay et al., 2021). Previous research (Tremblay et al., 2021; Zhang et al., 2010) has shown that, when cues are presented in isolation, English listeners do not use duration that much, and rely consistently more on vowel quality. Thus, vowel quality is a more consistent cue to lexical stress when cues are presented in isolation but, in naturalistic speech where cues are unmanipulated and available simultaneously, vowel quality and duration covary and contribute significantly to the identification of lexical stress.

The present study aims to provide novel tests for the Cue-Weighting Transfer Hypothesis by studying if Spanish-English bilinguals that differ in their language dominance are, in fact, transferring their cue weightings from the dominant language into the non-dominant language. This hypothesis has been previously tested with L2 listeners, focusing on the perception of lexical stress in English as a second language. However, as formerly explained, no research so far has tested this hypothesis in Spanish-English bilinguals who differ in their language dominance, nor has it focused on the production of lexical stress, in addition to perception, in this population. Our study aims to fill this gap, using as background previous research that has provided robust evidence for the Cue-Weighting Transfer Hypothesis in other languages.

Tremblay et al. (2021), for instance, studied the perception of English lexical stress in Dutch learners of English, and compared their results with those of native English speakers. As mentioned above, vowel quality is the most important cue in identifying lexical stress in English, whereas the most important cues in Dutch are duration and pitch. Results from a cue-weighting stress perception experiment revealed that Dutch listeners relied significantly less on vowel quality than English listeners, and more on suprasegmental cues like pitch and duration, indicating that participants in the experimental group (i.e., Dutch listeners) were transferring the use of acoustic cues that are important in their L1 in order to identify lexical stress in their L2 (Tremblay et al., 2021). Observing this type of L1-L2 transfer in aiding in the perception of a phonological phenomenon in the L2 represents direct support for the Cue-Weighting Transfer Hypothesis. These results are in line with previous research where Dutch learners of English were also found to transfer cues from the L1 to the L2 by relying more on suprasegmental cues like duration to process lexical stress in English (Cooper et al., 2002; Cutler et al., 2007). An additional finding from this study, however, correlates L2 proficiency with the amount of L1-L2 transfer observed, with Dutch listeners' reliance on vowel quality

increasing as their English proficiency increased (Tremblay et al., 2021). This correlate between L1-L2 transfer and proficiency is not specific to this population and has been replicated in other studies as well, suggesting that listeners are able to, as they learn a second language, progressively learn to use cues that play an important role in this L2 as well, even if this cue is not as relevant in their L1 (Weber and Cutler, 2006; Tremblay et al., 2012; Tremblay and Spinelli, 2014).

Together, these findings indicate that the perception of lexical stress can become more L2-like as proficiency in the second language increases. This raises the question of whether the same is true of language dominance. The present study seeks to answer this question by examining whether Spanish-English bilinguals who differ in their language dominance show more L2-like use of cues to perceive and produce lexical stress in English (i.e. whether they will increase their use of vowel reduction as a cue to perceive lexical stress in English as their dominance in English increases, given the fact that vowel quality is not a relevant cue for the perception of stress contrasts in Spanish, but it is in English).

In an additional study, Kim and Tremblay (2021) found similar support for a cue-based transfer, this time in Korean listeners' identification of lexical stress in English. In this study, a group of native English speakers and L2 learners of English from two dialects of Korean were chosen: (i) Gyeongsang Korean (GK), which does not have lexical stress but has lexical pitch accents (i.e. two words can be differentiated in meaning by pitch patterns alone), and (ii) Seoul Korean (SK), which has neither of these contrasts (no lexical stress, nor lexical tones) – rendering pitch as relevant for lexical contrasts in GK but not in SK. Native English speakers, as well as participants from both Korean dialects, completed a four-item sequence-recall task in English where words differed suprasegmentally through lexical stress. Results revealed that, in the f0-only condition (i.e. where words were manipulated for pitch but neutralized for duration and intensity), GK listeners significantly outperformed SK

listeners, suggesting that GK listeners were, in fact, relying on pitch more than the other two groups. These results provide direct support for the Cue-Weighting Transfer Hypothesis and suggest that if a particular cue plays a vital role in the L1, it can be used to process lexical stress in the L2, even if the L1 does not have lexical stress (Kim & Tremblay, 2021).

Similarly to Kim and Tremblay (2021), other studies have also tested different varieties of the same language, finding comparable L1-L2 transfer results. Qin et al., (2017) tested Standard Mandarin (SM) and Taiwan Mandarin (TM) learners of English in their processing of English lexical stress. Both dialects use f0 (pitch) as a primary cue to signal lexical tones. Standard Mandarin (SM), however, also has lexical stress and uses duration as a main cue to signal it, while Taiwan Mandarin (TM) has no word-level stress, and therefore does not use duration as a relevant cue. Participants from both dialects completed a sequence-recall task in English where naturally produced and resynthesized nonwords (i.e. where stress was intentionally manipulated across f0, duration, and intensity) were presented. Results revealed that while both SM and TM speakers successfully relied on pitch when this was the only cue present in the task (i.e., when the rest of the cues were neutralized), when duration was the only cue present TM speakers had more difficulty than SM speakers in perceiving lexical stress. This finding is in line with the previously discussed research (Tremblay et al., 2021; Kim & Tremblay, 2021; Tremblay & Spinelli, 2014; Weber & Cutler, 2006), showing once again support for a cue-based L1-L2 transfer: While only SM speakers were able to transfer their use of duration from the L1 to the L2 (because SM has lexical stress and TM does not), both SM and TM speakers were able to transfer their use of f0 from one phonological phenomenon in their L1s (i.e., lexical tones) to another phenomenon in their L2 (i.e., lexical stress).

Thus, it is not only the case that L2 learners can transfer the use of cues from the L1 to the L2 to process the same phonological phenomenon across languages (i.e., from lexical

stress *to* lexical stress), as observed in Tremblay et al. (2021) or Qin et al. (2017) when SM speakers transferred their use of duration (finding (ii)) from their L1 to their L2. It is also the case that L2 learners can transfer the use of cues from one phonological phenomenon in the L1 (i.e., lexical tones or lexical pitch contrasts) to a *different* one in the L2 (i.e., lexical stress) (Qin et al., 2017; Kim and Tremblay, 2021), implying that acoustic cues can be transferred both across languages (i.e., from the L1 to the L2) and across phonological contexts as well. Not only does the Cue-Weighting Transfer Hypothesis suggest that cues are weighted differently across languages, but also it indicates that the transfer observed from the L1 to the L2 is inclusive enough that an important cue in the L1 can be helpful in interpreting information in the L2, even if the L1 does not have the particular phenomenon that the L2 has.

Showing similar support for the Cue-Weighting Transfer Hypothesis, a subsequent study by Kim and Tremblay (2022) found that Seoul Korean L2 learners of English outperformed French listeners in the processing of English lexical stress, given the fact that Seoul Korean participants showed transfer of a cue to lexical contrasts in Korean that French does not use to the same degree. In this study, Kim and Tremblay (2022) examined whether second language learners' processing of lexical stress in English was facilitated when intonational cues signal a segmental contrast in the native language, as is the case with Seoul Korean but not with French. Neither of these two languages have lexical stress, but they do have similar intonational systems that differ in one crucial aspect: Seoul Korean has a tonal pattern that distinguishes fortis and aspirated segments from lenis ones, while French does not have that. This means that intonational tones can help distinguish segments in Korean (which encode words) but not in French (Kim & Tremblay, 2022). Because the L and H tonal cues serve to distinguish segments at the lexical level in Korean but not in French, when processing English lexical stress that was realized only with tonal cues (i.e. H on the stressed syllable), Seoul Korean listeners outperformed French ones. This advantage observed in

Korean learners of English suggests an L1-L2 transfer where intonational cues that signal a segmental contrast in the L1 (i.e. L and H tonal cues) can facilitate the processing of an intonationally-cued lexical stress in the L2 (Kim & Tremblay, 2022). This study further supports a cue-based transfer approach and, once again, indicates that L2 learners not only can transfer cues from the L1 to the L2, but they can also do so from one phonological phenomenon in the L1 (in this case, tonal cues) to a *different* one in the L2 (i.e. lexical stress), much like previous research (Qin et al., 2017; Kim & Tremblay, 2021) has shown.

The previously discussed research has dealt with the acoustic weightings to lexical stress in English. However, before beginning an investigation of cue-weighting transfer in Spanish-English bilinguals, as is the case in the present study, it is necessary to understand how cues to lexical stress are weighted in Spanish as well. A study by Ortega-Llebaria and Prieto (2009) dealt with the perception of word-level stress in Spanish, serving as a baseline in identifying which cues are used by Spanish speakers to signal lexical stress contrasts. In line with the Cue-Weighting Transfer Hypothesis, their study proposed that acoustic cues are weighted differently across languages, as is explained below.

While vowel quality is rendered the most relevant acoustic cue in the identification of lexical stress in English (Tremblay et al., 2021) given the fact that unstressed vowels are consistently reduced to a schwa ([ə]), the same is not true for Spanish. Vowel reduction does happen in some dialects of Spanish, such as the one spoken here in the Ciudad Juárez-El Paso area and, overall, in the state of Chihuahua, México, but it does not signal lexical contrasts, as is the case for English. In Spanish, vowel reduction may happen as a result of weakening and natural coarticulation when speaking (e.g., the word *pues* ('well') is often reduced from [pues] to [pəs] in naturalistic speech). However, this vowel reduction is never used to differentiate two words: [pues] to [pəs] are still understood as the same word *pues*. Thus, vowel quality is not a possible cue for the perception of lexical stress in this language, as

vowels are never reduced for this purpose. Unstressed vowels, while quieter and shorter to some degree, still maintain their full vowel qualities in the great majority of Spanish dialects (i.e., they are produced as either [a, e, i, o, u] and are not reduced to [ə]). For example, the words *papa* ('potato') and *papá* ('dad') are differentiated by stress, but both are pronounced with full, unreduced vowels: [ˈpa.pa] and [pa.ˈpa], respectively.

Through a word-identification task in which participants were presented with oxytone words (i.e., words stressed on the last syllable; e.g., *papá*) and paroxytone words (i.e., words stressed on the second-to-last syllable; e.g., *papa*) within phrases pronounced with a flat pitch melody, Ortega-Llebaria and Prieto (2009) investigated which acoustic cues and cue-interactions were used by Spanish speakers to perceive primary stress. Their results revealed duration and intensity to be the most significant cues used in Castilian Spanish when pitch accents were absent and suggest that, despite lacking vowel quality as a cue, Spanish has its own phonetic cues (i.e., duration and intensity) when identifying lexical stress (Ortega-Llebaria & Prieto, 2009). Because this research was performed using stimuli with a flat pitch melody, we have yet to find out how (if at all) our Spanish-dominant participants are utilizing pitch for the perception and production of lexical stress in English.

Similar results were found in a subsequent study investigating the acoustic correlates of stress between Catalan and Castilian Spanish (Ortega-Llebaria & Prieto, 2011). Through participants' exposure to oxytone and paroxytone words, similarly to the methodology employed in Ortega-Llebaria and Prieto (2009), results revealed that duration was once again a consistent cue used in the identification of lexical stress in both Catalan and Spanish, but the use of intensity was not as pervasive this time in either of these languages. Thus, duration seems to be the most consistent correlate of stress at the word level in Spanish (Ortega-Llebaria & Prieto, 2009; 2011), with other acoustic cues like intensity or pitch being used to a lesser degree.

The studies discussed above have direct implications for the field of Second Language Acquisition, as they deal with language transfer and provide evidence in support of the Cue-Weighting Transfer Hypothesis, suggesting that (i) acoustic cues are transferred from the L1 to the L2, (ii) they are weighted differently across languages (Tremblay et al., 2012; Tremblay et al., 2021), (iii) can be transferred from one phonological phenomenon in the L1 to another one in the L2 (Qin et al., 2017; Kim & Tremblay, 2021; Kim & Tremblay, 2022), and (iv) the perception of acoustic cues becomes more L2-like as listeners' proficiency in the second language increases (Weber and Cutler, 2006; Tremblay et al., 2012; Tremblay and Spinelli, 2014; Tremblay et al., 2021).

These studies have also shown that vowel quality is the most important cue for the perception of lexical stress in English (Tremblay et al., 2021) while duration seems to be the most consistent one in Spanish when pitch is held constant (Ortega-Llebaria & Prieto, 2009; 2011). Our study has yet to find out what happens when pitch is taken into consideration instead of being held constant (i.e., it is unclear whether or not our Spanish-dominant participants will use pitch in the perception and production of lexical stress in English). Given these observations, this project centers around the L1-L2 transfer observed across the literature and attempts to replicate previous findings, this time examining the effect of language dominance in a bilingual population where production and perception of lexical stress have been under-investigated. The present study aims to add to the literature by investigating which are the acoustic cues that Spanish-English bilinguals, specifically those in our Ciudad Juárez-El Paso region, use in the perception and production of lexical stress for English (i.e. their L2).

Given the fact that vowel quality is not a cue for the perception and production of word-level stress in Spanish (Ortega-Llebaria & Prieto, 2009), as vowels are rarely reduced in this language, the present study poses the following research question: Do Spanish-English

bilinguals show evidence of cue-weighting transfer from the dominant to the non-dominant language in perception and in production of lexical stress? Our study seeks to find further support for the Cue-Weighting Transfer Hypothesis, and for the idea that the bilingual mind is in a constant state of dynamism where language transfer and co-activation are – to a certain degree – inevitable. We hypothesize that Spanish-English bilinguals will show a greater use of duration in the perception and production of lexical stress in English, given the fact that Spanish is their first and dominant language, and we anticipate that they will increase their use of vowel quality as a function of their language dominance in English. We are, however, aware of the highly balanced and dynamic bilingualism observed in our region, and are open to the possibility that participants may show different perception and production strategies than the ones hypothesized here.

In the following sections, the two experiments performed for this project will be presented. The production experiment (Experiment 1) will be described first in Chapter 3, including its methodology, results, and discussion. After that, the perception experiment (Experiment 2) will be described in Chapter 4, including the same sections described for Experiment 1. The paper then offers a general discussion and conclusion section in Chapter 5 that discusses both experiments and provides an overall interpretation of the study as a whole.

CHAPTER 3 – PRODUCTION EXPERIMENT (EXPERIMENT 1)

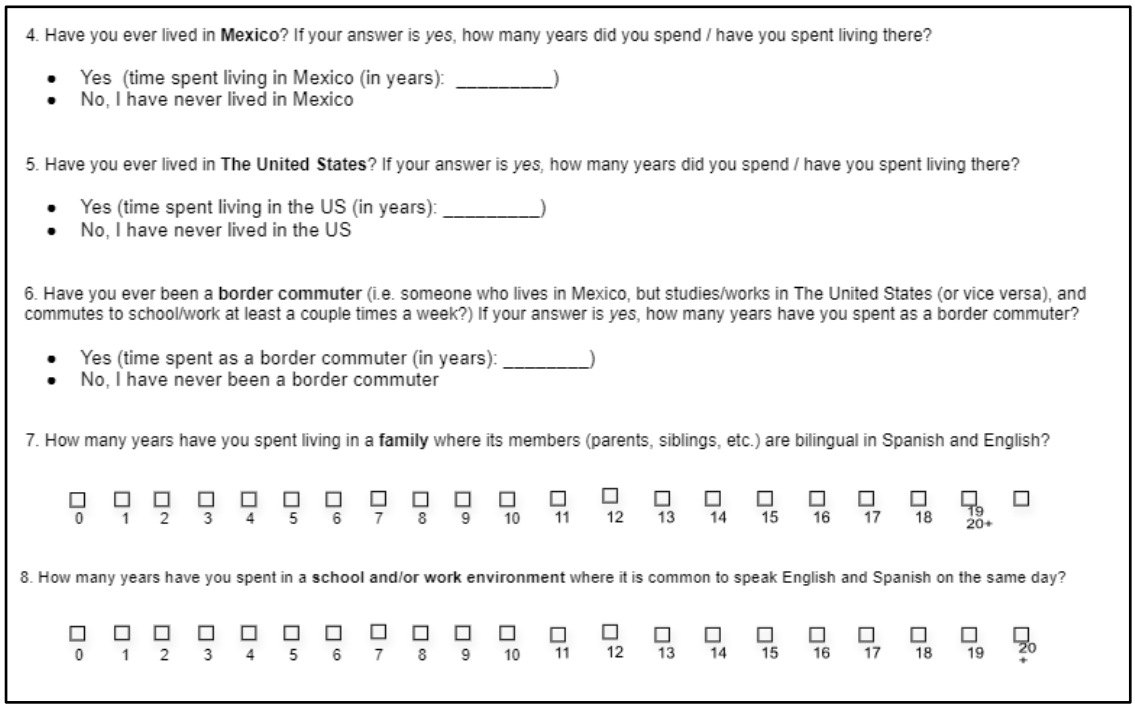
3.1 METHOD

A. PARTICIPANTS

Data from 24 Spanish-dominant and 32 English-dominant speakers were collected for this study. All participants were undergraduate students from the University of Texas at El Paso and were recruited through SONA, a research-oriented platform used within the university for participant recruitment. Because the highly dynamic bilingual situation in our region makes it difficult to find either entirely Spanish- or entirely English-monolinguals, our eligibility criteria focused on language dominance, allowing both monolinguals and bilinguals to participate, but placing them as either Spanish-dominant or English-dominant based on their age of acquisition (AoA) and overall use of each language. Spanish-dominant participants were classified as such if they had grown up in an entirely Spanish-speaking household and had been raised by Spanish-speaking parents/guardians. English-dominant participants were classified as such using the same criteria, but with English instead of Spanish (i.e. having grown up in an entirely English-speaking household and being raised by English-speaking parents/guardians).

In addition to a consent form, all participants completed a modified version of the Bilingual Language Profile (BLP) designed by Birdsong et al., (2012), which served as a language background information questionnaire where participants provided information about their knowledge, exposure to, and use of English and Spanish. This was completed by participants in writing, and their results were later entered into a spreadsheet for analysis. The decision to use a slightly modified version of this questionnaire arose from the realization that the original version contained some questions that were confusing and difficult to answer for some of our participants.

Specifically, question four of the original questionnaire (i.e., *How many years have you spent in a country/region where the following languages are spoken?*), which asked about each language (Spanish and English) separately, was edited, keeping in consideration that a significant portion of the student population at UTEP are border commuters (i.e., individuals who live in Ciudad Juarez but commute to El Paso on an everyday basis for school and/or work). These individuals, while having spent years working and/or studying in the United States, have technically always lived in Mexico, making question 4 difficult to answer. Because of this, 5 questions were added to/edited from the original questionnaire, shown in Figure 1 below, and represented a more accurate fit for our student population. A complete version of the BLP questionnaire used in this study may be found in Appendix A. This version of the BLP took approximately 10 minutes to complete.


4. Have you ever lived in **Mexico**? If your answer is *yes*, how many years did you spend / have you spent living there?

- Yes (time spent living in Mexico (in years): _____)
- No, I have never lived in Mexico

5. Have you ever lived in **The United States**? If your answer is *yes*, how many years did you spend / have you spent living there?

- Yes (time spent living in the US (in years): _____)
- No, I have never lived in the US

6. Have you ever been a **border commuter** (i.e. someone who lives in Mexico, but studies/works in The United States (or vice versa), and commutes to school/work at least a couple times a week?) If your answer is *yes*, how many years have you spent as a border commuter?

- Yes (time spent as a border commuter (in years): _____)
- No, I have never been a border commuter

7. How many years have you spent living in a **family** where its members (parents, siblings, etc.) are bilingual in Spanish and English?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

8. How many years have you spent in a **school and/or work environment** where it is common to speak English and Spanish on the same day?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

Figure 1. A depiction of the five questions that were edited from the original version of Birdsong's et al., (2012) Bilingual Language Profile questionnaire, in order to fit our student population more accurately.

Because our eligibility criteria were based on language dominance, a total of 20 participants (10 Spanish-dominant and 10 English-dominant) were chosen from the participant pool, leaving the rest of them excluded from the analysis for this particular study. This exclusion decision was made aiming to include those speakers that represented the most extreme sides of both dominance spectrums (i.e., those who were the *most* Spanish-dominant, and those who were the *most* English-dominant), and excluding from the analysis those participants whose dominance level was difficult to determine due to a highly-balanced usage of both languages, even if they had met the initial eligibility criteria (i.e., having grown up in an entirely Spanish- or entirely English-speaking household). Thus, our final participant selection included 10 Spanish-dominant speakers (9 female; 1 male) between the ages of 18 and 32 (M=21.2; SD=4.59) and 10 English-dominant speakers (4 female; 6 male) between the ages of 18 and 34 (M=21.2; SD= 4.87). Tables 1 and 2 below summarize participants' Age of Acquisition (i.e., the age at which they began to learn each language) for both Spanish and English, as well as the age at which they began to feel comfortable in each of these languages. We chose to focus on these two variables, as these shed further light into their current dominance spectrums.

From Table 1, it is evident that all Spanish-dominant speakers had learned Spanish since birth but acquired English later in childhood (mean age: 9.8; SD: 4.52) or even in late adolescence, as indicated by the range (7-17). Table 2, on the other hand, shows that the majority of English-dominant speakers learned English since birth (mean age: 0.5; SD: 1.58) and learned Spanish either in childhood (mean age: 7.2; SD: 2.77) or never at all, as indicated by five participants. Thus, while our Spanish-dominant participants are all Spanish-English bilinguals, the English-dominant group is composed of both English-Spanish bilinguals (at different degrees of Spanish proficiency, but with a native-like dominance of English) and

English-monolinguals as well. None of the participants reported having speech or learning impairments, and none reported speaking a language other than Spanish and/or English.

Table 1. Spanish-dominant participants' language history with English and Spanish. *AoA* refers to Age of Acquisition and *comfort* refers to the age where participants started feeling comfortable with a certain language. All measurements refer to *years*.

Spanish-dominant Speakers					
	Age	**AoA (English)**	**AoA (Spanish)**	**Comfort (English)**	**Comfort (Spanish)**
Mean (SD)	21.2 (4.59)	9.8 (4.52)	0 (0)	13.25 (3.45)	0 (0)
Range	18-32	7-17	0-0	9-18 (2 "not yet")	0-0

Table 2. English-dominant participants' language history with English and Spanish. *AoA* refers to Age of Acquisition and *comfort* refers to the age (in years) where participants started feeling comfortable with a certain language. All measurements refer to *years*.

English-dominant Speakers					
	Age	**AoA (English)**	**AoA (Spanish)**	**Comfort (English)**	**Comfort (Spanish)**
Mean (SD)	21.2 (4.87)	0.5 (1.58)	7.2 (2.77)	0.8 (2.53)	15 (3.46)
Range	18-34	0-5	4-11 (5 "never")	0-8	12-20 (6 "not yet")

In addition to the modified version of the BLP, participants also completed a Cloze Test (Brown, 1980), which served as a measurement of English proficiency. They were asked to read a story titled "Man and His Progress," where they had to fill-in the blanks using any word they felt was appropriate. Participants completed the task in writing, and their results were later entered to a spreadsheet as determinants of proficiency level. All 20 participants

included in the analysis obtained a score of 27/50 or higher, which is indicative of an appropriate upper-intermediate proficiency level, or higher. Table 3 below summarizes the Cloze Test results of each participant group, indicating their English proficiency.

Table 3. Cloze Test (Brown, 1980) results for both participant groups (out of 50 possible points).

Cloze Test Results		
	Spanish-dominant	**English-dominant**
Mean (SD)	38.2 (7.33)	40.9 (4.63)
Range	27-48	32-50

B. MATERIALS

The purpose of the production task was to determine which cues are being used to produce lexical stress by Spanish-English bilinguals, compared to those used by English-dominant speakers whose first language is English. The stimuli for this experiment included a combination of 12 oxytone words (i.e., stressed on the last syllable) with their corresponding 12 paroxytone counterparts (i.e., stressed on the penultimate syllable), yielding a total of 24 items. The 12 word-pairs used in this experiment are presented on Table 4, which shows that each pair was identical, except for their placement of lexical stress. The noun versions of these words have word-initial stress (*CONflict*), while the verb counterparts are stressed on the last syllable (*conFLICT*), and all of them showed some changes in vowel quality between the oxytone and paroxytone words, which allows the analysis to be focused on the acoustic correlates of lexical stress of interest to this study (i.e., vowel quality, duration, and pitch), keeping all other factors consistent. All words were controlled for frequency, taking into consideration their frequency values within the Corpus of Contemporary American English

(COCA) (Davies, 2008). The noun and verb versions of each of these words were matched for frequency, making sure that the mean values were similar across both syntactic categories (M = 3.15, SD = 0.70 for nouns; M = 3.28, SD = 0.63 for verbs). In addition, all chosen words were disyllabic in order to keep word length as identical as possible. To obtain a more naturalistic pronunciation, these words were elicited within a carrier phrase (*Mary says _____ again*). This decision was made based on the fact that words tend to have a different production when pronounced in isolation rather than when pronounced within speech, as is the case in everyday, naturalistic speech.

Table 4. List of words used in Production Experiment. Participants produced these words in a randomized order and within a carrier sentence (*Mary says _____ again*).

List of words elicited in production experiment	
Address (noun)	Address (verb)
Affect (noun)	Affect (verb)
Conduct (noun)	Conduct (verb)
Conflict (noun)	Conflict (verb)
Construct (noun)	Construct (verb)
Convict (noun)	Convict (verb)
Present (noun)	Present (verb)
Project (noun)	Project (verb)
Relapse (noun)	Relapse (verb)
Contract (noun)	Contract (verb)
Suspect (noun)	Suspect (verb)
Object (noun)	Object (verb)

C. PROCEDURES

Participants completed the experiment in person a quiet sound isolation booth within the Bilingual Speech Lab, located at the University of Texas at El Paso. They were audio-recorded with a stand microphone (Blue Yeti Multi-Pattern Condenser) using version 2.4.2 of the Audacity recording and editing software at a sampling frequency of 44,100 Hz. Participants were seated at an approximate 12-inch distance from the microphone. After reading the instructions in Microsoft PowerPoint, portrayed in a Dell Latitude 7200 laptop, they were asked to complete a practice session first, which contained four practice items (*PREsent* (noun), *reLAPSE* (verb), *preSENT* (verb), *RElapse* (noun)). This practice session served as a familiarization phase for participants to understand how the actual experiment would work. In the actual testing phase, participants were then presented with the 24 items three times (total of 72 words) in a randomized order, each on a different slide. The decision to elicit each word three times was made with the purpose of having three options to choose from in the analysis portion of our study. It may be the case that one production is better than the other two, as participants may sometimes stutter, have an unclear pronunciation, or mispronounce a verb as a noun (or vice versa). For the purpose of this study, no filler items or distractors were used in order to keep the length of the task manageable. For the data analysis, participants' first pronunciation of each word was chosen for the analysis, unless it was inaccurately pronounced. If this was the case, the following production of that word was chosen and, if none of the three productions for a particular word were accurate, this word would be discarded from that participant's productions.

Participants were asked to pronounce the word on the screen out loud within the carrier phrase *Mary says* ____ *again*. As shown in Figure 2, each slide contained the carrier phrase and the target word in bold with a parenthesis next to it, which indicated whether they

should pronounce the word as a noun or as a verb. After the participant produced the word in the carrier phrase, they moved on to the following slide using the arrow keys on the keyboard.

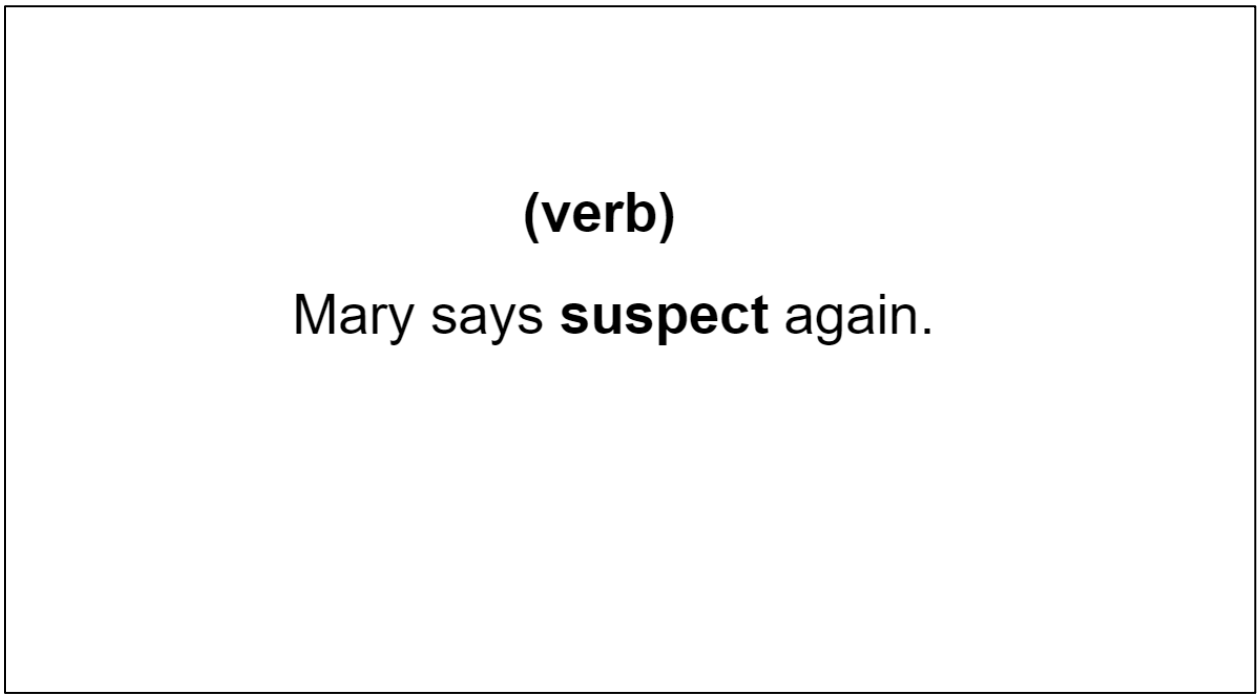


Figure 2. A sample of what each slide in the production experiment looked like for participants. The only thing that changed across slides was the word in bold, and the word in parenthesis (whether they should pronounce each word as a noun or a verb).

All recordings were stored in a password-protected computer and later acoustically analyzed in Praat, as explained in the *Analysis* section below. Completion of this production task lasted approximately 10 minutes.

D. DATA ANALYSIS

The initial analysis for this production experiment was done using the Praat (version 6.4.07) speech analysis software (Boersma, 2008). For this analysis, the first correctly produced 24 words (i.e., the first round of the experiment) from each participant were considered. Words were first analyzed for whether or not they were produced with the correct

stress pattern (as judged impressionistically by the author). That is, the words were coded for whether or not they were pronounced as a verb when they were supposed to be, or as a noun when needed. Words that were produced correctly in the first round (correct pronunciation, produced without hesitations or background noise) were analyzed acoustically. If a word was inaccurately produced, the second repetition was used and, consequently, if the second production was incorrect, the third one was used. Cases where all three instances of a word were inaccurately produced were discarded from that particular participant, as can be observed in Table 5 below. Once all accurate word productions had been chosen, a tier was created on Praat to segment the first and second vowel from each word, and a script was then used to extract the mean F1 and F2, mean F0, and duration for each vowel.

The mean first and second formant frequencies (F1 and F2, respectively) were analyzed. For each participant, the Euclidean distance was calculated between stressed and unstressed vowels in the first syllable and between stressed and unstressed vowels in the second syllable. The Euclidean distance is the distance between the F1-F2 coordinates for stressed vowels and the F1-F2 coordinates for unstressed vowels. This was done based on the mean frequencies across test items because not every pair of vowels had measurements (e.g., when frequencies could not be tracked or when some words had to be excluded from the analyses). Mixed-effects linear models were then conducted on participants' Euclidean distance, with syllable (1, 2), language dominance (English, Spanish), and their interaction as fixed effects and with participant as random effect. This was done using the lme4 package in R (Baayen et al., 2008). If language dominance affects the degree of vowel reduction in unstressed vowels, Spanish-dominant participants should show a smaller Euclidean distance between stressed and unstressed vowels compared to English-dominants participants, and this should be true of both the first and second syllable, although the degree of vowel reduction may differ depending on the position of the syllable in the word.

The mean F0 and duration of vowels were also analyzed. Mixed-effects linear models were conducted on participants' mean F0 and duration of vowels in each syllable, with stress (stressed, unstressed), syllable (1, 2), language dominance (English, Spanish), and their interaction as fixed effects and with participant and item as random effects. This was done using the lme4 package in R (Baayen et al., 2008). If language dominance interacted with the other variables, this factor was releveled with Spanish-dominant speakers as baseline and the model was rerun. If language dominance affects the production of mean F0 and duration as suprasegmental cues to stress, we should find a significant interaction between stress and language dominance, with Spanish-dominant speakers showing a greater effect of stress than English-dominant speakers. This would suggest that Spanish-dominant speakers rely more on suprasegmental cues to stress than English-dominant speakers.

3.2 RESULTS

Table 5 below represents each participants' proportion of accurate responses in the production experiment. A word produced by a participant was labeled as accurate if it was pronounced, across all three rounds, with the expected stress pattern—that is, as a verb when the experiment required a verb pronunciation, or vice versa (i.e. if pronounced as a noun when it was instructed to be pronounced as a noun). A value of 1 represents correct productions across all 24 experimental items, whereas the lowest score in Table 5 (0.750) represents 18 accurate productions and 6 inaccurate ones. Only accurate productions were analyzed acoustically. As shown in Table 5, out of 480 tokens elicited in the experiment (24 items *X* 20 participants), 451 were correctly produced, representing 93.96% of the total productions. 29 productions in total (representing productions from the first block for all participants) were inaccurate and thus excluded from the analyses, corresponding to 6.04% of the data.

Table 5. Participants' accuracy in the production experiment. A value of 1 signifies correct productions across all 24 experimental items.

Participant ID	Production Accuracy	Correct Productions (out of 24)
ED2	0.917	22
ED12	0.875	21
ED13	0.958	23
ED18	1.000	24
ED19	0.875	21
ED20	0.958	23
ED21	1.000	24
ED22	0.833	20
ED30	0.958	23
ED31	0.958	23
SD3	0.875	21
SD4	1.000	24
SD5	0.958	23
SD6	1.000	24
SD8	0.917	22
SD11	0.750	18
SD12	1.000	24
SD15	1.000	24
SD16	0.958	23
SD23	1.000	24
Total number of correct productions:		**451**

A. F1 and F2 as a function of syllable, stress, and language dominance

Figure 3 below presents a scatterplot showcasing the F1 (*y* axis) and F2 (*x* axis) coordinates of every participant's produced stressed and unstressed vowels as a function of syllable (*Syllable 1* on the left; *Syllable 2* on the right) and language dominance (*English-dominant* on the top; *Spanish-dominant* on the bottom). This figure illustrates the Euclidean distance across participants' productions (i.e., the distance between the stressed and unstressed vowels), where each individual dot represents one vowel and the triangles correspond to the mean vowel position across all participants in stressed (blue) and

unstressed (red) syllables. The wider the distance between two triangles, the more different these two vowels are from each other in their F1 and F2 values; accordingly, the less space there is between two triangles, the more similar the stressed and unstressed vowels are to each other.

From Figure 3, it is evident that distance between stressed and unstressed vowels is greater in Syllable 1 than in Syllable 2, suggesting there is a greater degree of vowel reduction in Syllable 1 than in Syllable 2. It is also evident that, in this first syllable, the distance between stressed and unstressed vowels is greater for English-dominant participants. That is, Spanish-dominant speakers have less distance between their stressed and unstressed vowels in Syllable 1, compared to English-dominant speakers, who show a wider distance between them.

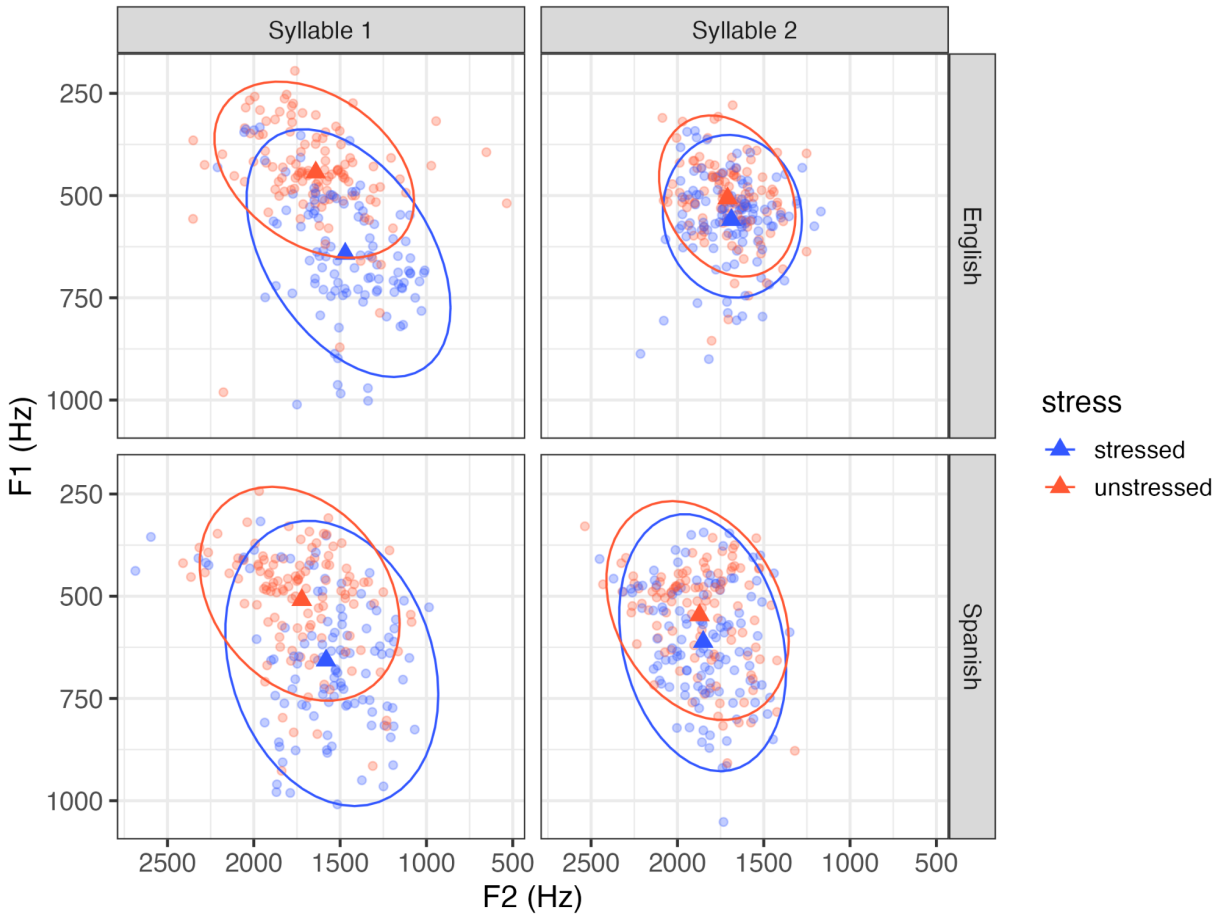


Figure 3. Scatterplot of all produced vowels. F1 and F2 are plotted as a function of syllable, stress, and language dominance. Each circle represents one produced vowel.

In line with what is represented in Figure 3, Table 6 below contains the results of the linear mixed-effects model on this Euclidean distance, taking syllable position and language dominance as fixed effects and participants as random effect. This table reflects what is observed in Figure 3, showing significant effects for syllable position ($p < .003$) and language dominance ($p < .05$). The fact that significant effects are observed in these two domains means that (i) there are smaller distance values for Syllable 2 than for Syllable 1, and that (ii) there is also a smaller distance between stressed and unstressed vowels for Spanish-dominant speakers than for English-dominant ones. Thus, the results from both Figure 3 and Table 6 suggest that, overall, Spanish-dominant speakers show significantly less vowel reduction than English-dominant participants.

Table 6. Results of linear mixed-effects model on Euclidean distance with syllable (1, 2) and language dominance as factors, with only participant as random effect.

	Estimate	SE	df	*t* value	Pr(>|t|)
(Intercept)	291.600	30.900	35.100	9.430	.004 ***
Syllable (Syllable 2)	–291.600	40.000	18.000	–5.49	.003 ***
Language Dominance (Spanish)	–88.800	43.700	35.100	–2.03	.05 *
Syllable (Syllable 2) Language dominance (Spanish)	94.100	56.600	18.000	1.660	.11

B. Fundamental frequency (F0) as a function of syllable, stress, and language dominance

Figure 4 is similar to Figure 3 above but, instead of showing F1 and F2 to represent vowel distance, it now takes into consideration mean F0 (i.e., pitch) across the vowel, plotted

as a function of syllable position (*Syllable 1* on the top left; *Syllable* 2 on the top right), stress (*stressed vowels* on bottom left; *unstressed vowels* on bottom right), and language dominance (*English-dominant* on top half; *Spanish-dominant* on bottom half). From the analysis in Figure 4, a salient pattern arises: The effect of pitch is much more noticeable in Syllable 1 than in Syllable 2, and the two language dominance groups show an opposing pattern: English-dominant speakers produce higher pitch in stressed vowels than in unstressed ones, while Spanish-dominant speakers appear to show the opposite (i.e., lower pitch production on stressed vowels, and higher pitch production on unstressed vowels).

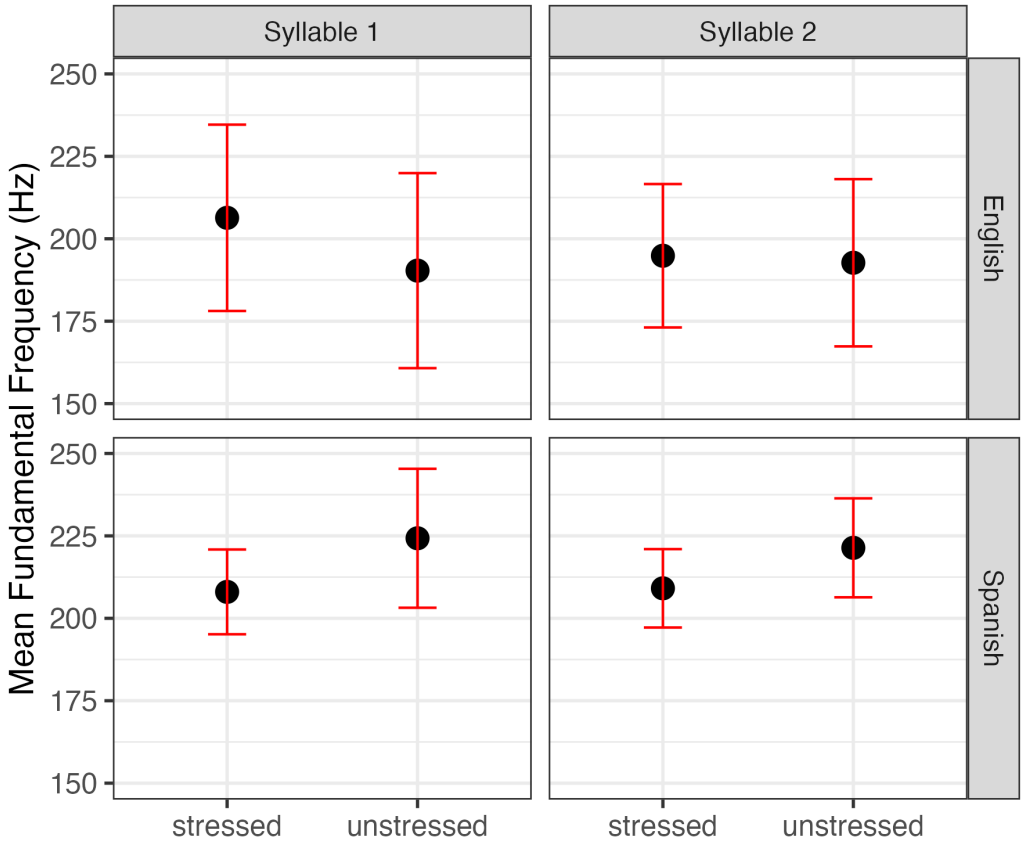


Figure 4. Participants' production of fundamental frequency (Hz), plotted as a function of syllable, stress, and language dominance.

The results presented in Table 7 confirm the patterns observed in Figure 4 above. This table shows the values for a mixed-effects model on mean F0 with stress, syllable, and

language dominance as fixed effects and with participant and item as random effects. These results show significant effects for stress (p <.005) and syllable position (p <.014), and a significant interaction between stress and language dominance (p < .001). Together, these results indicate that: (i) for English-dominant speakers' production of *Syllable 2*, mean F0 is lower on unstressed syllables and higher on stressed syllables; (ii) for English-dominant speakers' production of stressed syllables, *Syllable 2* has a lower mean F0 than *Syllable 1,* an effect that can be extended to Spanish-dominant speakers given the lack of interaction between syllable position and language dominance; and (iii) the two language dominance groups differ in the effect of stress they show.

Table 7. Results of linear mixed-effects model on mean F0 with stress (stressed, unstressed), syllable (1, 2), and language dominance as factors, with participant and item as random effects.

	Estimate	SE	df	*t* value	Pr(>|t|)
(Intercept)	210.107	8.627	34.550	24.350	< 0.000***
Stress (unstressed)	-19.221	6.788	281.590	-2.830	0.005 **
Syllable (Syllable 2)	-16.637	6.702	271.785	-2.480	0.014*
Language dominance (Spanish)	0.482	11.843	31.088	0.040	0.968
Stress (Unstressed) Syllable (Syllable 2)	15.214	9.626	89.974	1.580	0.117
Stress (Unstressed) Language Dominance (Spanish)	30.169	8.911	732.440	3.390	0.001***
Syllable (Syllable 2) Language Dominance (Spanish)	14.735	8.851	732.277	1.660	0.096
Stress (Unstressed) Syllable (Syllable 2) Language Dominance (Spanish)	-12.495	12.504	733.145	-1.000	0.318

To ascertain the nature of the interaction between stress and language dominance, the same mixed-effects model was rerun on the participants' mean F0 after releveling language dominance with Spanish-dominant speakers as baseline. The model with the releveled factor shows that the effect of stress does not reach significance for Spanish-dominant speakers'

production of stressed syllables ($t = 1.8$, $p = .073$), confirming that the interaction between stress and language dominance come from English-dominant speakers showing a higher mean F0 in stressed vowels than in unstressed vowels and from Spanish-dominant speakers not showing such an effect.

C. Syllable duration as a function of syllable, stress, and language dominance

Figure 5 below shows syllable duration across participants' productions, plotted as a function of syllable (*Syllable 1* on the left; *Syllable 2* on the right), stress (*unstressed vowels* on the top of each diagram; *stressed vowels* on the bottom), and language dominance (*English-dominant speakers* on the top half; *Spanish-dominant speakers* on the bottom half). Duration is plotted in milliseconds (Ms) in the *x* axis.

As shown in Figure 5, across both language dominance groups, stressed syllables seem to be longer than unstressed ones; this is an expected, non-surprising effect since, across languages, it is widely known that stressed syllables are consistently longer and louder than unstressed ones. In this particular figure, however, the difference in duration is more noticeable in *Syllable 1* than in *Syllable 2* (i.e. in S*yllable 2*, both stressed and unstressed syllables seem to have rather similar durations, whereas this is not the case in S*yllable 1*). In addition, for *Syllable 2*, Spanish-dominant speakers seem to produce longer stressed syllables than English-dominant speakers.

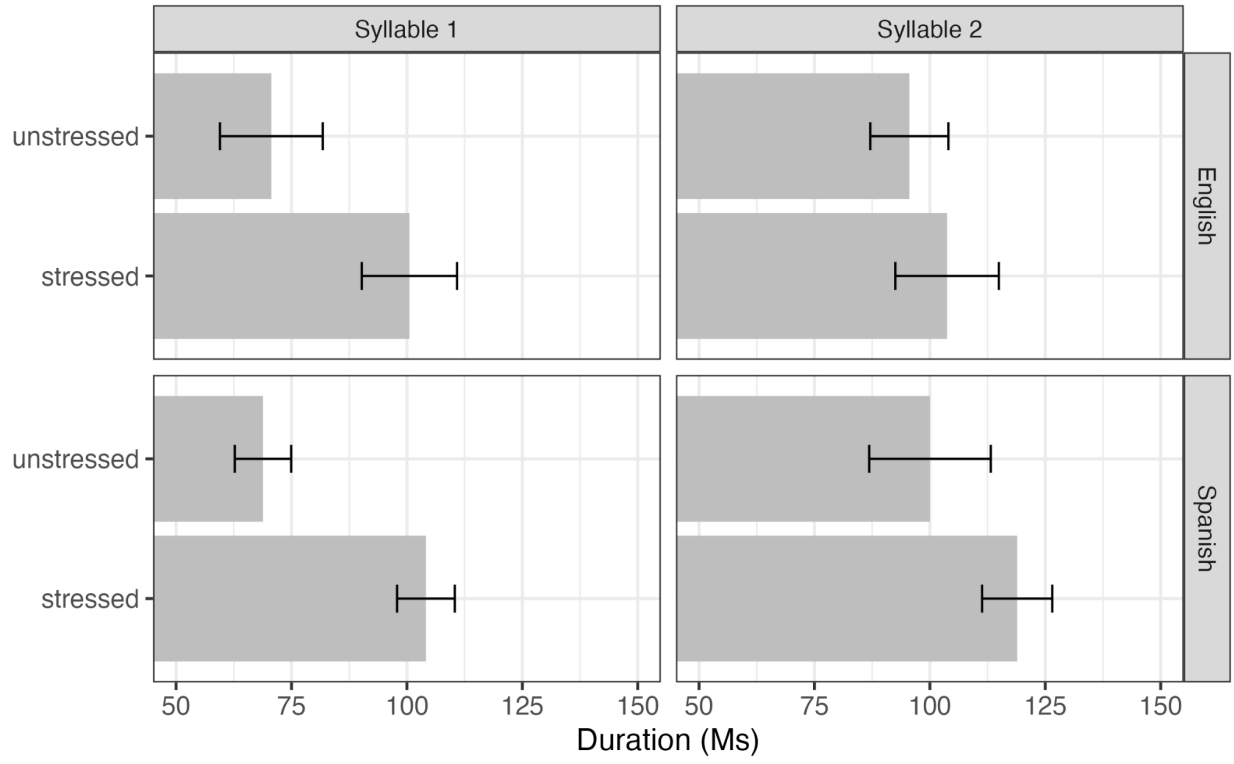


Figure 5. Syllable duration (Ms) across productions, plotted as a function of syllable, stress, and language dominance.

Table 8 shows the results of a linear mixed-effects model on duration with stress, syllable number, and language dominance as fixed effects, and with participant and item as random effects. This table shows a significant effect of stress, a significant interaction between stress and syllable number, and a significant interaction between syllable and language dominance, supporting the patterns observed in Figure 5. Together, the results for this analysis suggest that: (i) English-dominant speakers' production of duration in *Syllable 1* is shorter for unstressed vowels than for stressed syllables; (ii) the effect of stress is larger for English-dominant speakers' production *Syllable 1* than for their production of *Syllable 2*; and (iii) for stressed syllables, the two groups differ in the effect of syllable they show.

Table 8. Results of linear mixed-effects model on duration with stress (stressed, unstressed), syllable (1, 2), and language dominance as factors, with participant and item as random effects.

	Estimate	SE	df	*t* value	Pr(>|t|)
(Intercept)	0.101	0.005	49.330	20.170	< 0.002***
Stress (Unstressed)	-0.033	0.006	35.104	-5.690	0.002***
Syllable (Syllable 2)	0.002	0.006	35.104	0.390	0.702
Language Dominance (Spanish)	0.005	0.005	34.227	0.920	0.366
Stress (Unstressed) Syllable (Syllable 2)	0.024	0.011	26.177	2.230	0.034*
Stress (Unstressed) Language Dominance (Spanish)	-0.004	0.004	855.007	-0.880	0.3783
Syllable (Syllable 2) Language Dominance (Spanish)	0.011	0.004	855.007	2.630	0.009**
Stress (Unstressed) Syllable (Syllable 2) Language Dominance (Spanish)	-0.008	0.006	856.137	-1.300	0.194

To verify the nature of the interaction between syllable and language dominance, the same mixed-effects model was rerun on the participants' duration after releveling language dominance with Spanish-dominant speakers as baseline. The model with the releveled factor revealed a significant effect of syllable position ($t = 2.34$, $p <. 025$), which was not significant for English-dominant speakers as the baseline. This effect indicates that Spanish-dominant speakers produce the vowel in *Syllable 2* as longer than that in *Syllable 1* when the syllable is stressed. The model with the releveled factor also does not reveal an interaction between stress and syllable position ($t = 1.5$, $p = .145$), indicating that the effect of syllable extends to both stressed and unstressed syllable, suggesting some word-final lengthening in their productions, and the effect of stress also extends to both *Syllable 1* and *Syllable 2*.

3.3 DISCUSSION

Our production experiment sought to investigate which acoustic cues are being used by Spanish-dominant and English-dominant speakers in their production of English lexical stress. More specifically it explored how, and if, language dominance modulates differences in stress production. That is, whether acoustic cues are weighted differently depending on which language speakers are more comfortable in. The acoustic cues analyzed in this experiment were vowel quality (i.e., vowel reduction), pitch (i.e., F0), and duration. From the three linear mixed-effects model analyses performed on each of these cues separately, it is evident that various differences arise as a result of language dominance effects.

Our first analysis took into consideration the Euclidean distance between stressed and unstressed vowels in order to analyze differences in vowel reduction across both language dominance groups. In this first analysis, we found significant effects for syllable position and language dominance, indicating that (i) vowel reduction is significantly more prominent in Syllable 1 than in Syllable 2, and (ii) that this vowel reduction effect is stronger in English-dominant speakers. These two findings indicate that, overall, Spanish-dominant speakers use vowel reduction to a significantly lesser degree than English-dominant speakers, and are in line with previous perception research (Tremblay et al., 2021), which has found vowel quality to be the most prominent acoustic cue used for stress perception by native English speakers.

Thus, it is not only the case that vowel reduction is used by English-dominant listeners in the perception of lexical stress. We now know as a result of this experiment that it is also widely used in its production, and is rendered a more significant acoustic cue for English-dominant speakers than for Spanish-dominant speakers. Moreover, the fact that a difference is observed because of language dominance is indicative of support for the Cue-

weighting Transfer Hypothesis, which states that acoustic cues are weighted differently across languages (Tremblay et al., 2021).

Our second linear mixed-effects model analysis investigated the effects of pitch in the production of lexical stress. This analysis yielded two interesting findings resulting from differences in language dominance and syllable position: (i) we saw that pitch differences are much more salient in Syllable 1 than in Syllable 2, and (ii) that the two language dominance groups show different pitch patterns. The first finding indicates that, in Syllable 1, syllables are produced with a significantly different pitch pattern, depending on whether they are stressed or unstressed whereas, for Syllable 2, syllables are produced with a relatively similar pitch pattern, regardless of their stress status. Furthermore, our second finding indicates that this significant pitch difference observed in Syllable 1 is manifested differently in both language dominance groups: English-dominance speakers produce higher pitch in stressed syllables and lower pitch in unstressed syllables, whereas Spanish dominant speakers produce the reverse numerical pattern (i.e., lower pitch in stressed syllables, and higher pitch in unstressed ones). We also know that, when the mixed-effects model was rerun on the participants' F0 after releveling language dominance with Spanish speakers as the baseline, the effect of stress did not reach significance for Spanish-dominant speakers' production of stressed syllables. Given that these results did not reach significance, it is suggested that Spanish listeners did not show a reliable effect of pitch.

So far, it is unclear why different pitch patterns arise across both language dominance groups. This was an unexpected finding, since it is widely known that stressed syllables often have a resulting correlation with other acoustic cues (i.e., stressed syllables tend to be longer, louder and, overall, more prominent than unstressed ones). Thus, while having a higher pitch pattern in stressed syllables would be an expected finding (like English-dominant speakers showed), it is more difficult to explain why Spanish-speakers did not show this effect and, in

fact, demonstrated a tendency towards the reverse pattern. One possiblity may be that pre-nuclear post-tonal pitch rise—a rise in pitch that Spanish speakers tend to produce *after* the stressed syllable (Olson & Ortega, 2010)—may have obscured the results by causing the pitch to rise on the unstressed syllable either when it followed the stressed syllable in the target word or when it followed the stressed syllable *says* in the carrier phrase *Mary says* _____, thus obscuring the relevance of pitch as a correlate of lexical stress in Spanish. Another possibility could be that this unexpected finding resulted from having a relatively small participant sample from which is hard to make generalizations or, similarly, we also have to account for the possibility that, because of our small sample, there could have been outliers in our participant group. That is, if one or two participants showed an extremely different pattern from the rest of the group, this could have skewed the results, resulting in an unexpected pattern that is not as reliable. Plans for the future continuation of this research would be to (i) include the rest of our participants in the analysis to have more reliable results and (ii) to analyze each participants' data separately and look at each participant individually to account for any outliers that may be skewing the data. Thus, the results from this second analysis should be taken with reservations.

Finally, our third analysis investigated the effects of duration and found that, across both language dominance groups, stressed syllables were longer than unstressed ones. This was an expected result since, as specified above, stressed syllables often correlate with other acoustic cues (i.e., stressed syllables tend to be consistently longer than unstressed ones). A key difference that arose from this analysis was that the difference in duration is a lot more salient in Syllable 1 than in Syllable 2. That is, Syllable 1 has significantly different lengths depending on whether or not it is stressed, whereas Syllable 2 has relatively similar lengths, regardless of their stress status. In terms of language dominance, this analysis found that, overall, Spanish-dominant speakers show a larger syllable effect than English-dominant

speakers, indicating that Spanish-dominant speakers produce significantly longer syllables (both Syllables 1 and 2) when they are stressed than when they are unstressed, whereas English-dominant speakers only show this effect in Syllable 1. For Syllable 2, English-dominant speakers produce similar durations, regardless of whether or not the syllable is stressed. These findings were further confirmed once the mixed-effects model was rerun on participants' duration after releveling language dominance with Spanish-dominant speakers as the baseline. This further analysis found a significant effect of syllable position, which was not initially found with English-dominant participants as the baseline, suggesting that Spanish-dominant speakers' productions of stressed vowels in Syllable 2 are longer than in Syllable 1. Additionally, the lack of interaction found between stress and syllable position in this further analysis indicates that Spanish speakers show more word-final lengthening than English speakers do (i.e., they show longer second syllables across stressed and unstressed syllables, whereas this is not the case for English-dominant speakers). These findings are in line with previous research on native Spanish speakers (Ortega-Llebaria & Prieto, 2009; 2011), which suggests that, because vowel reduction is not as strong of a cue for the perception of lexical stress in Spanish, other acoustic cues like duration are rendered more important and used to a higher degree. Thus, we now know that it is not only the case that duration is widely used for the perception of lexical stress, as was found in Ortega-Llebaria & Prieto (2009; 2011). We also now know that duration is an important cue in production and, in line with previous Cue-Weighting research (Tremblay et al., 2021), these findings show that acoustic cues are weighted differently across languages.

Overall, this production experiment showed that (i) Spanish-dominant speakers show vowel reduction to a significantly lesser degree than English-dominant speakers, (ii) English dominant and Spanish-dominant speaker show different patterns in their utilization of pitch, and (iii) for stressed syllables, Spanish-dominant speakers have a larger effect of duration

than English speakers indicating that, possibly, duration is a stronger cue for lexical stress production in Spanish than in English. Whether or not the same effects are observed in perception is to be seen in our second experiment.

CHAPTER 4 – PERCPETION EXPERIMENT (EXPERIMENT 2)

4.1 METHOD

A. PARTICIPANTS

The participants who completed the production experiment also completed the perception experiment (see Chapter 3)

B. MATERIALS

This stress perception experiment included auditory stimuli from a pre-existing experimental task used in Tremblay et al. (2021). These auditory stimuli were produced by a female speaker of American English, and included the elicitation of two different nouns that vary solely in their placement of lexical stress: *desert* (*DEsert*) and *dessert* (deSSERT). As explained in Tremblay et al. (2021), the cleanest audiorecording of each of these words was selected for acoustic manipulations. Based on these selected pronunciations of *desert* and *dessert*, different auditory stimuli were created in seven steps that varied from word-initial stress (step 1; *DEsert*) to word-final stress (step 2; *deSSERT*) in three dimensions: vowel quality, pitch, and duration (see Tremblay et al. (2021) for details on acoustic manipulations). For the purpose of this experiment, intensity was neutralized across all stimuli. Thus, the resulting manipulations yielded 147 auditory stimuli that came from three 7x7 matrices (each varying in two dimensions while keeping the third one constant): (1) vowel quality x pitch matrix (duration neutralized), (2) vowel quality x duration matrix (pitch neutralized), and (3) pitch x duration matrix (vowel quality neutralized). The resulting 147 tokens were presented three times to participants, yielding a total of 441 trials of *desert* and *dessert* manipulated across different acoustic dimensions. In addition, the experimental task included a practice session to familiarize participants with the upcoming task, which consisted of 12 practice stimuli where lexical stress was not manipulated. That is, it was realized across all three

dimensions, with vowel quality, pitch, and duration being all the way in step 1 (*DEsert*) or at step 7 (*deSSERT*). Thus, in total, the complete experiment included 453 tokens and lasted about 25 minutes (for more information about the acoustic manipulations, see Tremblay et al., 2021).

C. PROCEDURES

Participants completed the stress perception experiment in a quiet sound isolation booth after having completed the language background questionnaire (BLP) and the production experiment previously mentioned (Experiment 1). The experiment was delivered in a Dell Latitude 7200 laptop using the Gorilla Experiment Builder (www.gorilla.sc) software. Participants were told they were going to hear either *desert* or *dessert* across the whole experimental procedure and were instructed to press 1 on the keyboard if they thought they heard *desert*, and 2 if they heard *dessert*. In order to hear the stimulus, participants needed to press the spacebar, allowing them to complete the experiment at their own pace.

All participants reached an accuracy of 83% or higher in the practice session, which consisted of the 12 auditory stimuli described in the materials section above. Participants then began the actual experiment, which included the 441 tokens in a fully randomized order within three blocks. When participants selected either *1* or *2* on the keyboard, the next trial began after 1000 ms. Because the experiment may have seemed repetitive to the participants, in order to avoid the possibility that participants would start choosing answers randomly, they were instructed to take a brief 30-second break if they felt it necessary and to come back to the experiment once they felt ready. During this break, however, participants did not leave the isolation booth at any point, nor did they engage in any other activity that could distract them from the experiment. The complete experimental procedure lasted approximately 25 minutes.

D. DATA ANALYSIS

Participants' *DEsert* and *deSSERT* selections were coded as 1 and 0, respectively, and they were analyzed using logit mixed-effects models using the lme4 package in R (citation). The three stimuli matrices (vowel quality x pitch, vowel quality x duration, pitch x duration) were analyzed separately. The fixed effects were the centered step for each of the two acoustic dimensions in a given stimulus matrix (–3 to 3), language dominance (English, Spanish), and their interactions as fixed effects, and participant and item as random effects. If language dominance interacted with the fixed effects, the factor was releveled with Spanish-dominant listeners as baseline, and the model was rerun to determine if the effects of the acoustic dimension remained significant. If participants show an effect of language dominance on perception, we expect to find an interaction between the manipulated acoustic dimensions and language dominance, with Spanish-dominant listeners showing a weaker effect of vowel quality but stronger effects of pitch and duration compared to English-dominant listeners.

4.2 RESULTS

A. Vowel quality by pitch stimuli (duration neutralized)

Figure 6 below presents participants' responses when the acoustic stimuli varied on a seven-point scale in vowel quality and pitch, with duration neutralized at step 4 across all word items. The left diagram shows the results for English-dominant listeners, while the right one shows those for Spanish-dominant ones. The *x* axis corresponds to the seven-step continuum of vowel quality, where 1 corresponds to word-initial stress (*DEsert*) and 7 to word-final stress (*deSSERT*). The *y* axis represents this same seven-step continuum from word-initial to word-final stress, but this time corresponding to pitch. This means that, across each step of the continuum, words were gradually manipulated from a word-initial stress

stage where *DEsert* was easily perceived, all the way to a word-final stress stage where *deSSERT* was easily perceived, yielding manipulations of these words in the middle steps (2-6) that could result in variations of perception across participants.

These gradual manipulations across steps are informative, as they help determine which acoustic cues listeners are relying on the most, particularly when the cues conflict, in order to identify a word as having word-initial or word-final lexical stress. The colors in the figure represent the proportion of participants' *DEsert* vs. *deSSERT* selections, with 1 corresponding to selection of word-initial stress (*DEsert*) and 0 corresponding to word-final stress perception (*deSSERT*). This means that, the darker the color in each of the diagrams, the more *DEsert*-like participants' perception was, and vice versa: the lighter the color, the more *deSSERT*-like a word item was perceived in the experiment.

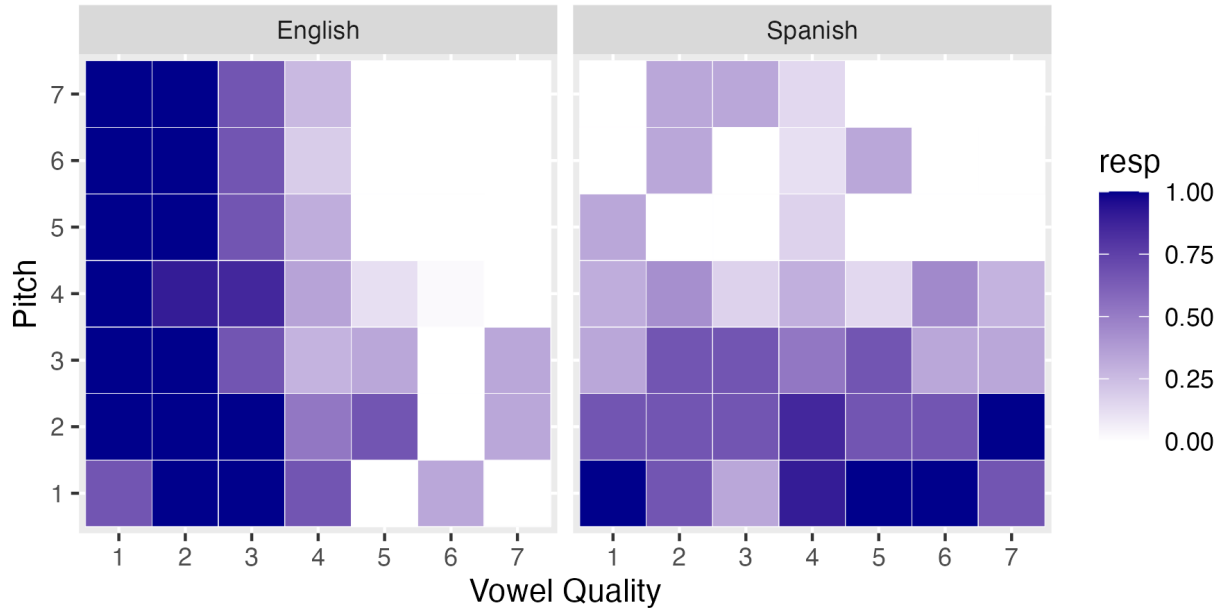


Figure 6. Participants' proportions of *DEsert* (1) vs. *deSSERT* (0) perception when the stimuli varied by vowel quality (*x* axis) and pitch (*y* axis), with duration neutralized at step 4.

The *vowel quality by pitch* results suggest that English-dominant listeners' selection of word-initial stress responses (*DEsert*) decreases as the steps in the vowel quality and pitch

continuums increased, and Spanish-dominant listeners' selection of word-initial stress responses (*DEsert*) decrease as well though not to the same degree for vowel quality. Table 9 reports the results for the mixed effects model on participants' responses when the presented stimuli varied by vowel quality and pitch, with duration neutralized at step 4. These results show a significant fixed effect of vowel quality, a significant fixed effect of pitch, and a significant interaction between vowel quality and language dominance, thus confirming the pattern of results observed in Figure 6.

Table 9. Results of logit mixed-effects model with best fit on participants' responses when the stimuli varied by vowel quality and pitch, with duration neutralized (step 4). SE = standard error.

	Estimate	**SE**	***z* value**	***p***
(Intercept)	0.072	0.127	0.570	0.570
Vowel Quality	-0.737	0.048	-15.450	<0.002 ***
Pitch	-0.364	0.044	-8.280	<0.002 ***
Language Dominance (Spanish)	-0.116	0.159	-0.730	0.470
Vowel Quality × Pitch	0.012	0.024	0.510	0.610
Vowel Quality × Language Dominance (Spanish)	0.436	0.050	8.720	<0.002 ***
Pitch × Language Dominance (Spanish)	-0.062	0.047	-1.330	0.180
Vowel Quality × Pitch × Language Dominance (Spanish)	-0.020	0.025	-0.780	0.430

To better understand the nature of the interaction observed, the same mixed-effects model was conducted on participants' *DEsert* selection, but with the language dominance factor releveled with Spanish-dominant listeners as baseline. The model with the releveled factor also revealed significant fixed effects of vowel quality ($z = 7.47$, $p < 001$) and pitch ($z = –10.47$, $p < .001$), with the size of the effect of vowel quality being smaller than that for English-dominant listeners and thus explaining the significant interaction.

This means that English-dominant speakers relied significantly more on vowel quality to perceive lexical stress than Spanish-dominant speakers and that, in terms of pitch, the two

language dominance groups do not significantly differ in their use of this cue, as no significant interaction between language dominance and pitch was found.

B. Vowel quality by duration stimuli (pitch neutralized)

Figure 7 below presents English-dominant (left diagram) and Spanish-dominant (right diagram) listeners' responses when the acoustic stimuli presented to them in the experiment varied by vowel quality and duration. This figure depicts the same information as Figure 6 above but replacing pitch with a seven-step continuum for duration on the *y* axis this time, where 1 corresponds to word-initial stress (*DEsert*) and 7 corresponds to word-final stress (*deSSERT*). Because this analysis looks at the interaction between vowel quality and duration, pitch was neutralized at step 4 across all word items considered here. Just like in Figure 6, 1 the color scale corresponds to word-initial stress perception, and 0 corresponds to word-final stress perception: The darker the color in each of the diagrams, the more *DEsert*-like participants' perception was, and vice versa: the lighter the color, the more *deSSERT*-like a word item was perceived in the experiment.

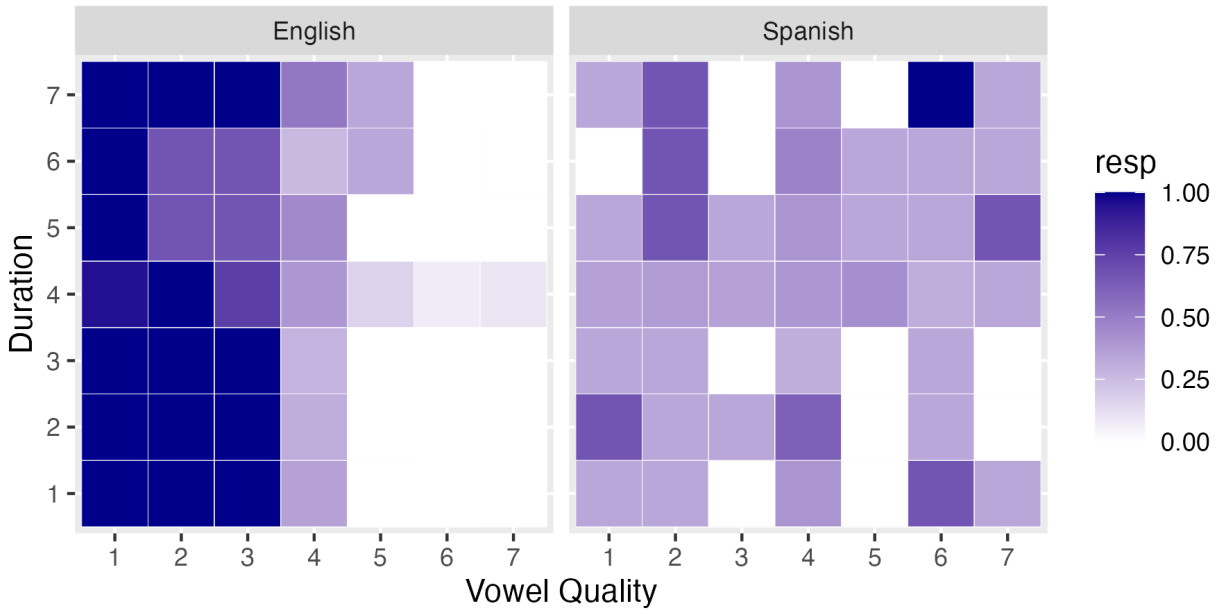


Figure 7. Participants' proportions of *DEsert* (1) vs. *deSSERT* (0) perception when the stimuli varied by vowel quality (*x* axis) and duration (*y* axis), with pitch neutralized at step 4.

Table 10 below contains the results of the mixed-effects model on participants' responses when the presented stimuli varied by vowel quality and duration. The results in this table show significant fixed effects of vowel quality (p <.002) and duration (p <.002) and confirm what is seen in Figure 7. English-dominant listeners' perception of *DEsert* (word-initial stress) decreased as the steps in the vowel quality and duration continua increased, as indicated by the negative coefficients. Additionally, the mixed-effects model also yielded a significant interaction between vowel quality and language dominance (p < .002), with Spanish-dominant listeners appearing to show a smaller effect of vowel quality than English-dominant participants. Conversely, the lack of interaction between language dominance and duration suggests that the two groups do not differ in their use of this cue.

Table 10. Results of logit mixed-effects model with best fit on participants' responses when the stimuli varied by vowel quality and duration. SE = standard error.

	Estimate	SE	*z* value	*p*
(Intercept)	-0.170	0.136	-1.250	0.210
Vowel Quality	-0.831	0.046	-18.010	<0.002 ***
Duration	-0.268	0.040	-6.700	<0.002 ***
Language Dominance (Spanish)	-0.229	0.181	-1.270	0.210
Vowel Quality × Duration	0.024	0.023	1.060	0.290
Vowel Quality × Language Dominance (Spanish)	0.476	0.052	9.170	<0.002 ***
Duration × Language Dominance (Spanish)	0.024	0.046	0.530	0.600
Vowel Quality × Duration × Language dominance (Spanish)	-0.022	0.026	-0.860	0.390

Again, to further examine the nature of the interaction between vowel quality and language dominance, the same model was rerun after releveling the language dominance factor with Spanish-dominant listeners as baseline. The model with the releveled factor yielded significant effects of vowel quality (z = 10.04, p < .001) and duration (z = –6.97, p

< .001), with the effect of vowel quality again being smaller for Spanish-dominant listeners than for English-dominant listeners, thus clarifying the nature of the observed interaction.

Together, these results suggest that Spanish-dominant listeners use vowel reduction to a lesser degree than English-dominant listeners, supporting once again the idea that vowel reduction is an important indicator for the perception of lexical stress in English, which is not necessarily the case in other languages like Spanish.

C. Pitch by duration stimuli (vowel quality neutralized)

Figure 8 below shows participants' responses when the presented stimuli varied by pitch and duration on a seven-step continuum, with vowel quality neutralized at step 4 across all word items. This means that there was some vowel reduction in the first and second syllables of all presented stimuli. Just like in Figures 6 and *7*, the *x* and *y* axes represent a seven-step continuum that goes from word-initial stress in step 1 (*DEsert*) to word-final stress in step 7 (*deSSERT*), with the manipulations for pitch being presented on the *x* axis, and the manipulations for duration presented on the *y* axis. Similarly, the color represents participants' perceptions of *DEsert* vs. *deSSERT*, with 1 (i.e. dark purple) corresponding to the former and 0 (i.e. white) to the latter.

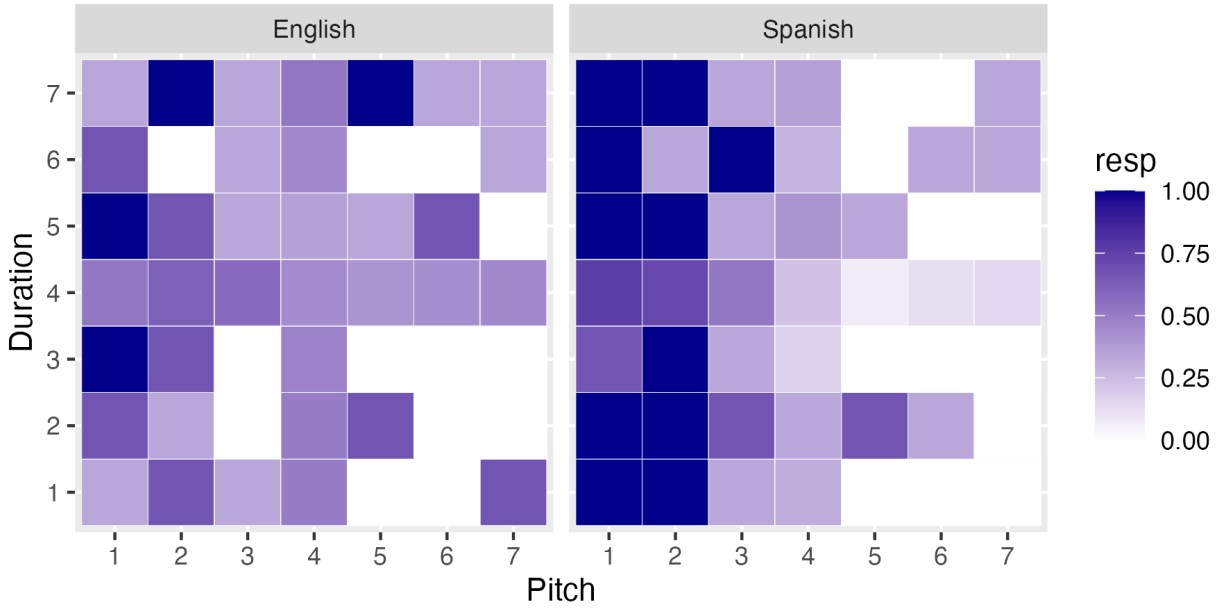


Figure 8. Participants' proportions of *DEsert* (1) vs. *deSSERT* (0) perception when the stimuli varied by pitch (*x* axis) and duration (*y* axis), with vowel quality neutralized at step 4.

In addition, Table 11 below contains the results for the mixed-effects model on participants' responses when the stimuli varied by pitch and duration. The results in Table 11 reflect what is observed in Figure 8, showing significant fixed effects of both pitch and duration, indicating that English-dominant listeners' perception of *DEsert* (word-initial stress) significantly decreased as pitch and duration were gradually manipulated from step 1 to step 7. Unlike the previous vowel *quality by pitch* and *vowel quality by duration* analyses, this *pitch by duration* analysis does not show a significant interaction with language dominance in any of the cues, suggesting that Spanish-dominant listeners show the same pattern of results as English-dominance listeners.

Table 11. Results of logit mixed-effects model with best fit on participants' responses when the stimuli varied by pitch and duration. SE = standard error.

	Estimate	SE	*z* value	*p*
(Intercept)	-0.210	0.095	-2.210	0.027 *
Pitch	-0.366	0.036	-10.090	<0.002 ***
Duration	-0.118	0.036	-3.320	0.001 ***
Language Dominance (Spanish)	-0.011	0.120	-0.090	0.929
Pitch × Duration	0.001	0.018	0.080	0.939
Pitch × Language Dominance (Spanish)	-0.069	0.042	-1.640	0.102
Duration × Language Dominance (Spanish)	-0.064	0.041	-1.580	0.114
Vowel Quality × Pitch × Language Dominance (Spanish)	-0.010	0.0211	-0.500	0.619

4.3 DISCUSSION

The present study used a cue-weighting stress perception task to investigate how English-dominant and Spanish-dominant participants weighted acoustic cues in perceiving lexical stress in English, and sought to investigate how (and if) language dominance modulates the weighting of these cues.

Our results showed that, overall, English-dominant participants use vowel reduction in the perception of lexical stress to a significantly higher degree than Spanish-dominant listeners. This was confirmed both by our *vowel quality by pitch* and the *vowel quality by duration* analyses, where significant fixed effects for vowel quality were observed in both language dominance groups, but the size of the effect was found to be significantly smaller for Spanish-dominant listeners than for English-dominant ones. These findings support previous studies (Tremblay et al., 2021) where vowel reduction has been shown to be a crucial acoustic cue in the identification of lexical stress in English, more so than in other languages. Additionally, the lack of interaction between language dominance and pitch in the *vowel quality by pitch* analysis suggests that English-dominant and Spanish-dominant participants were showing similar perception patterns, both using pitch to a certain degree for the identification of stress.

This is in line with previous research (Ortega-Llebaria & Prieto, 2009) that has shown that, despite lacking vowel quality as a cue, Spanish has other phonetic cues for the identification of word-level stress. Their research, however, found duration and intensity to be the most significant cues in the perception of stress. A possible explanation for the asymmetrical findings (in terms of pitch) between the present study and that of Ortega-Llebaria & Prieto's (2009) could be that their lexical stimuli did not contain pitch cues (i.e., they kept pitch neutralized), potentially inclining participants to rely more heavily on cues like duration or intensity. Our *vowel quality by duration* analysis, however, did find significant fixed effects for duration in both language dominance groups and did not find an interaction between language dominance and duration, suggesting that both Spanish-dominant and English-dominant participants are behaving similarly in their use of this cue. In line with Ortega-Llebaria & Prieto's (2009; 2011) research, this suggests that Spanish-dominant participants do seem to use duration to some degree. Thus, from the first two analyses (*vowel quality by pitch* and *vowel quality by duration*), it is evident that (i) English-dominant listeners are using vowel reduction to a significantly higher degree than Spanish-dominant listeners and that (ii) Spanish-dominant speakers are using duration and pitch instead, supporting the Cue-Weighting Transfer Hypothesis, which suggests that listeners' cue weightings are affected by language dominance.

Our third analysis (i.e., *pitch by duration*) supports the suggestions made above, having found significant effects for both pitch and duration, but no interaction between language dominance and any of these two cues. This suggests that English-dominant speakers use, to a certain degree, duration and pitch as relevant cues for the identification of stress, and that Spanish-dominant participants do not differ from English-dominant ones in the use of these two cues. Therefore, as demonstrated in our three analyses, and in line with our posed research question, Spanish-English bilinguals do show evidence of cue-weighting transfer

from the dominant to the non-dominant language in the perception of stress. We know from previous cue-weighting research (Tremblay et al., 2021) that vowel reduction has been found to be the main cue for the perception of stress in English while, in the absence of this cue, Spanish uses other cues to do so (Ortega-Llebaria & Prieto, 2009; 2011). Our English-dominant participants demonstrated a stronger use of vowel reduction, while our Spanish-dominant participants demonstrated a significantly smaller use of this cue and a use of duration and pitch instead, supporting the idea that cues are weighted differently in each language and, now, additionally suggesting that, even in cases where listeners are highly proficient in both languages, language dominance still plays an important role in shaping how acoustic cues are weighted for the perception of stress. These findings add to previous cue-weighting literature that has tested cross-linguistic differences of lexical stress from a proficiency perspective (Cooper et al., (2002); Cutler et al., (2007); Quin et al., (2017); Kim & Tremblay (2021); Tremblay et al., (2021); Kim & Tremblay (2022)), but this time suggesting that, even when proficiency is high in both languages, the effect of language dominance should be considered, as it is strong enough to dictate how cues are weighted.

CHAPTER 5 – GENERAL DISCUSSION AND CONCLUSION

The present study sought to investigate if Spanish-dominant and English-dominant speakers show evidence of cue-weighting transfer from the dominant to the non-dominant language in their perception and production of lexical stress. Both of our experiments confirmed cross-linguistic differences and provide robust support for the Cue-Weighting Transfer Hypothesis, suggesting that speakers weight acoustic cues differently, depending on how informative they are for lexical contrasts in their L1 (Tremblay et al., 2021).

Both of our experiments analyzed the following three acoustic cues: vowel quality, pitch, and duration, and found differences resulting from language dominance effects. Our production experiment showed that (i) English-dominant speakers use vowel reduction to a significantly higher degree than Spanish-dominant speakers, (ii) both language dominance groups show different patterns in their use of pitch, and (iii) for stressed syllables, Spanish-dominant speakers show a larger use of duration than English-dominant speakers.

Furthermore, our perception experiment showed that (i) English-dominant listeners use vowel reduction significantly more than Spanish-dominant listeners to perceive lexical stress, and that (ii) given the significant fixed effects found for duration and pitch, and the lack of interaction found between language dominance and these two cues, both English-dominant and Spanish-dominant speakers are using these cues to a certain degree. Thus, while both groups use all three analyzed cues to perceive lexical stress, certain differences stem from language dominance effects. The use of vowel quality is significantly stronger in English-dominant speakers, leading Spanish-dominant speakers to rely more on duration and pitch instead, relative to English-dominant speakers' reliance on these cues.

The findings from both experiments not only support a cue-weighting approach, but also suggest that, in addition to the proficiency effects found in previous cue-weighting studies (Cooper et al., (2002); Cutler et al., (2007); Quin et al., (2017); Kim & Tremblay

(2021); Tremblay et al., (2021); Kim & Tremblay (2022)), language dominance can also contribute to differences in how acoustic cues are weighted across languages. It is not only the case that unbalanced bilingualism results in cue-weighting differences, as this study indicates that these can be observed in participants who are highly proficient in both languages but display different language dominance spectrums.

The findings from both of our studies answer our research question, showing that participants are in fact transferring their weightings of acoustic cues from their dominant to their non-dominant language. Given the fact that both of our experiments were performed in English, this conclusion can be extended for our Spanish-dominant group, as our findings suggest that these participants were transferring their acoustic cue weightings from Spanish to perform both perception and production tasks in English. Future plans for this research include implementing the same type of experiments presented here, but this time in Spanish, to observe whether or not English-dominant participants are transferring their acoustic cue weightings from English to Spanish as well. Moreover, future plans for continuation of this research also include statistically analyzing the relationship between perception and production, as the present study provides a comparison but does not statistically investigate how similar or different perception and production are from each other, and whether or not the weightings of acoustic cues remain the same across perception and production.

As per weaknesses of the study, an important issue to mention pertaining to our production experiment is the fact that the task could have perhaps benefitted from having a slightly more visual design. Our production task asked participants to pronounce a word either as a verb or as a noun, indicating this inside parenthesies (see Figure 2). Throughout the data collection process, it was evident that some participants did not exactly know the difference between these two lexical categories (i.e., verb vs. noun), which caused some of them to produce words inaccurately, resulting in excluded productions that could have

otherwise contributed to our data analysis. Future implementations of this task should include visual aids that can help participants understand which word we are trying to elicit from them (e.g., adding a picture of a gift next to the words *present (noun)* when trying to elicit the noun form of *present* (i.e., *PREsent*)).

Despite the discussed weaknesses and plans to continue and improve this research in the future, the present study has yielded informative results and suggests that, besides proficiency, language dominance should be taken into consideration when analyzing the weightings of acoustic cues across languages. While proficiency refers to the amount of knowledge a speaker has for a particular language, or to how well they are able to handle each of the different language skills (i.e., reading, writing, speaking, listening), language dominance deals more with the amount of preference a speaker has for a language (Gertken et al., 2014). Thus, a bilingual individual may be highly proficiency in their two languages but have more language dominance in one of their languages relative to their other one. Our study indicates that the highly proficient bilinguals in our region can handle both languages with ease, but still behave differently depending on the language dominance spectrum they belong to. Much like previous research has shown (Tremblay et al., 2021), English-dominant speakers were found to consistently rely on vowel reduction to produce and perceive lexical stress and, in the absence of vowel quality as a cue for stress distinctions in Spanish (Ortega-Llebaria & Prieto, 2009), Spanish-dominant speakers were shown to have their own repertoire of acoustic cues that are used instead of vowel reduction, such as duration and pitch.

Understanding these weighting differences is relevant, as they have implications for the fields of Second Language Acquisition (SLA) and language pedagogy. Second language learners of English may sometimes struggle to grasp the concept of two words being differentiated solely by stress, especially since, as illustrated in this study, the primary cues

used to perceive and produce stress may vary across languages. Taking these cross-linguistic differences into consideration highlights the importance of analyzing lexical stress contrasts not only within but *across* languages as well. While segmental information that concerns specific sounds is often taught to second language learners of English in language classes (e.g. differentiating between [b] and [v]), suprasegmental information, such as lexical stress, is seldom addressed in second language teaching. Thus, as L2 learners of English learn the language, they might not be aware of the weight that lexical stress carries in contrasting two words from one another. The present study encourages language educators and instructors to pay the necessary attention to creating lessons and designing classroom materials that deal, in addition to segmental differences, with suprasegmental information like lexical stress, creating a more holistic learning process for second language learners, and a more complete understanding of intonational patterns in the target language.

Overall, our study provides robust support for the Cue-Weighting Transfer Hypothesis, supporting previous findings but adding new discoveries to the literature that suggest that, in addition to proficiency, the weightings of acoustic cues can be modulated by language dominance (i.e, they can transferred from the dominant to the non-dominant language). Future research may want to focus on testing language dominance in other highly bilingual regions where language contact is prominent to test whether or not the same language dominance effects are observed in other language pairs.

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APPENDIX

BLP questionnaire used in testing session: Questions in yellow are the ones added to/modified from the original questionnaire.

Bilingual Language Profile: English-Spanish

We would like to ask you to help us by answering the following questions concerning your language history, use, attitudes, and proficiency. This survey was created with support from the Center for Open Educational Resources and Language Learning at the University of Texas at Austin to better understand the profiles of bilingual speakers in diverse settings with diverse backgrounds. The survey consists of 21 questions and will take less than 10 minutes to complete. This is not a test, so there are no right or wrong answers. Please answer every question and give your answers sincerely. Thank you very much for your help.

I. Biographical Information

Participant number (given to you at the beginning of the testing session): ___

Today's Date: _____/_____/_____

Age: _____

☐ Male / ☐ Female

Current place of residence: city/state _____ country_____

Highest level of formal education: ☐ Less than high school ☐ High school ☐ Some college ☐ College (B.A., B.S.) ☐ Some graduate school ☐ Masters ☐ PhD/MD/JD ☐ Other: _____

II. Language history

In this section, we would like you to answer some factual questions about your language history by placing a check in the appropriate box.

1. At what age did you **start learning** the following languages?

English

☐ Since birth ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

Spanish

☐ Since birth ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

2. At what age did you **start to feel comfortable** using the following languages?

English

☐ As early as I can remember ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+ ☐ Not yet

Spanish

☐ As early as I can remember ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+ ☐ Not yet

3. How many years of **classes (grammar, history, math, etc.)** have you had in the following languages (primary school through university)?

English

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

Spanish

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

4. Have you ever lived in **Mexico**? If your answer is *yes*, how many years did you spend / have you spent living there?

☐ Yes (time spent living in Mexico (in years): _____)
☐ No, I have never lived in Mexico

5. Have you ever lived in **The United States**? If your answer is *yes*, how many years did you spend / have you spent living there?

☐ Yes (time spent living in the US (in years): _____)
☐ No, I have never lived in the US

6. Have you ever been a **border commuter** (i.e. someone who lives in Mexico, but studies/works in The United States (or vice versa), and commutes to school/work at least a couple times a week?) If your answer is *yes*, how many years have you spent as a border commuter?

☐ Yes (time spent as a border commuter (in years): _____)
☐ No, I have never been a border commuter

7. How many years have you spent living in a **family** where its members (parents, siblings, etc.) are bilingual in Spanish and English?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

8. How many years have you spent in a **school and/or work environment** where it is common to speak English and Spanish in a same day?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20+

III. Language use

*In this section, we would like you to answer some questions about your language use by placing a **circle** around the appropriate box. Total use for all languages in a given question should equal 100%. For example:*

English	0%	10%	20%	30%	40%	50%	60%	**70%**	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	**30%**	20%	10%	0%

9. In an average week, what percentage of the time do you use the following languages **with friends**?

English	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%

10. In an average week, what percentage of the time do you use the following languages **with family**?

English	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%

11. In an average week, what percentage of the time do you use the following languages **at school/work**?

English	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%

12. When you talk to yourself, how often do you **talk to yourself** in the following languages?

English	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%

13. When you count, how often do you **count** in the following languages?

English	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Spanish	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%

IV. Language proficiency

In this section, we would like you to rate your language proficiency by giving marks from 0 to 6.

0= not well at all *6= very well*

14. a. How well do you speak **English**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. How well do you speak **Spanish**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

15. a. How well do you understand **English**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. How well do you understand **Spanish**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

16. a. How well do you read **English**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. How well do you read **Spanish**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

17. a. How well do you write **English**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. How well do you write **Spanish**? ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

V. Language attitudes

In this section, we would like you to respond to statements about language attitudes by giving marks from 0-6.

0=disagree *6=agree*

18. a. I feel like myself when I speak **English.** ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. I feel like myself when I speak **Spanish.** ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

19. a. I identify with an **English-speaking** culture. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. I identify with a **Spanish-speaking** culture. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

20. a. It is important to me to use (or eventually use) **English** like a native speaker. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. It is important to me to use (or eventually use) **Spanish** like a native speaker. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

21. a. I want others to think I am a native speaker of **English**. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

b. I want others to think I am a native speaker of **Spanish**. ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6

CURRICULUM VITA

Natalia Irene Minjarez Oppenheimer is a graduate Master's student at the University of Texas at El Paso (UTEP). She obtained a Bachelor of Arts in Linguistcs from this same university in May 2021 with Summa Cum Laude honors, and will be obtaining a Master of Arts in Linguistics with a concentration in Applied Linguistics in May 2024.

Her interests within the field of Linguistics include bilingualism, second language acquistion, second language teaching, and sociolinguistics. She has collaborated in research projects that deal with with bilingualism (e.g., *Changing pronoun interpretations across languages: Discourse priming in Spanish-English bilingual speakers* (Contemori & Minjarez Oppenheimer, 2022)) and sociolinguistcs (e.g., *Spanish Loyalty and English Prestige in the Linguistic Landscape of Ciudad Juárez, México* (Mazzaro et al., 2024)). Most recently, her research has been focused on suprasegmental aspects of speech production and perception in bilingual speakers, which is what her thesis project deals with.

Natalia has additionally worked as a Teaching Assitant for the Department of Latin-US and Linguistics for two consecutive years, and has acquired valuable teaching experience and hands-on practice in a classroom setting. Her journey as a graduate student has shaped her both as a researcher and as a language educator. If they wish, readers may reach out to Natalia via email at nminjarezo@miners.utep.edu.