Perception and Production of Spanish Lexical Stress by Spanish Heritage Speakers and English L2 Learners of Spanish

Ji-Young Kim

1. Introduction

In the literature on second language phonology, numerous studies have investigated the influence of the speech sounds from the first language (L1) to the second language (L2) (Flege et al., 1995; Flege et al., 1999; Kuhl et al., 2003), while relatively little research has been done in the opposite direction, i.e., the influence from the L2 to the L1. Thus, the present study explores a possible influence from the L2 to the L1 by focusing on heritage speakers in the United States (US).[1] It is of interest whether heritage speakers, who are more dominant in English (L2; majority language) than their heritage language (L1; minority language), have their heritage language influenced by their English. The present study also examines whether heritage speakers show similar patterns in their perception and production of the heritage language. Previous studies support that language-specific patterns emerge in speech perception prior to speech production (Imada et al., 2006; Kuhl et al., 2008; Moore & Guan, 2001; Perani et al., 2003). Although heritage speakers have been exposed to the heritage language from infancy, given that the heritage language is spoken far less frequently than it is heard (Hakimzadeh & Cohn, 2007; Kim, 2010), a discrepancy between these two domains may be found. Focusing on heritage speakers of Spanish and their perception and production of Spanish lexical stress, this study investigates whether heritage speakers of Spanish are able to perceive stress contrasts in Spanish (e.g., *páso* 'I pass' vs. *pasó* 'he/she passed') and whether they successfully distinguish these contrasts in their production. Heritage speakers' performance was compared to that of monolingual native speakers of Spanish (i.e., control group) and English L2 learners of Spanish in order to determine whether they show a target-like behavior and if not whether their non-target-like behavior is due to influence from English.

2. Background

2.1. Previous studies on heritage language phonology

According to Chang (2010), heritage speakers are comparable neither to monolingual native speakers nor to L2 learners. Studies have found that heritage speakers often have greater command of the heritage language than L2 learners, yet not to the extent as monolingual native speakers (Au et al.,

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[1] Heritage speakers in the US are defined as "[individuals] who are raised in home where a non-English language is spoken, speak or merely understand the heritage language, and are to some degree bilingual in English and the heritage language" (Valdés, 2001). As the broad definition implies, heritage speakers do not comprise a homogeneous group, but differ in many aspects such as the age and context of acquisition of the heritage language, the type of input received, and schooling (Montrul, 2008; Valdés, 2001). The present study will limit its scope to first generation US-born heritage speakers who are born and raised in the US.

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2008; Kim et al., 2009; Montrul, 2008; 2010; Montrul et al., 2008; Rothman, 2007). Therefore, although heritage speakers have a more native-like command of the heritage language than L2 learners, it is unlikely that they are able to control both the heritage language and English the same way as two monolinguals (Flege, 1999; Grosjean, 2010, Valdés, 2001). Although currently more research is conducted on heritage speakers' grammatical knowledge of the heritage language (Kim et al., 2009; Montrul, 2010; Montrul et al., 2008; Rothman, 2007), there has been less attention to their phonological system. Flege's Speech Learning Model (SLM) (Flege, 1995; Flege, 1999; Flege et al., 2003) claims that L1 and L2 speech sounds coexist in one phonetic space and, in a combined L1+L2 phonetic space, mutual interference between L1 and L2 sound categories inevitably occurs. This implies that phonetic transfer does not occur only from the L1 to the L2, but also from the L2 to the L1 (Flege, 1995). The strength and direction of the influence depends on factors such as the age of acquisition of the L2, and the amount of input and use of the two languages (Grosjean, 2010; Guion, 2003). Given that heritage speakers are generally more dominant in English than the heritage language, it is expected that their phonological system of the heritage language is influenced by that of English. Although studies on heritage language phonology are still scarce, there have been some studies, both on heritage language vowels (Godson, 2004; Ronquest, 2013; Willis, 2005) and consonants (Kim, 2011, 2012; Knightly et al., 2003; Simon, 2010), that support this view. For instance, Ronquest (2013) found that, although not to the extent of schwa in English, Spanish heritage speakers reduced some of their Spanish vowels when these vowels appeared in unstressed contexts. Regarding consonants, Knightly et al. (2003) found that Spanish heritage speakers with limited use of Spanish (i.e., "childhood overhearers") produced Spanish /b, d, g/ with more prevoicing than late L2 learners, but to a lesser degree than native Spanish speakers. A similar pattern was found in Kim (2011, 2012) in which heritage speakers of Spanish produced Spanish /b, d, g/ with less prevoicing than native Spanish speakers.

Compared to studies at the segmental level, relatively little research has been done at the suprasegmental level. Ronquest (2013) is one of the few studies that that have investigated heritage speakers' prosody. Ronquest (2013) compared Spanish heritage speakers' durational differences between stressed and unstressed vowels to those of monolingual speakers of Spanish reported in Marín Gálvez's (1995) study. Results showed that durational differences were much greater for the heritage speakers than for the monolingual speakers, a possible explanation to which is that heritage speakers' unstressed vowels underwent vowel reduction, which may have led to shorter vowel duration in the unstressed condition. Due to limited research in this area, the present study intends to fill in the gap in the literature by examining the influence from English to Spanish in Spanish heritage speakers' use of Spanish lexical stress. Moreover, the present study investigates not only heritage speakers' production of Spanish lexical stress, but also their perception, studies of which are non-existent in the literature.

2.2. Discrepancy between heritage language speech perception and production

Studies on infants' perception and production of speech support that language-specific patterns emerge in speech perception prior to speech production (deBoysson-Bardies, 1993; Imada et al., 2006; Kuhl & Meltzoff, 1996; Kuhl, et al., 1992; Kuhl et al., 2006; Kuhl et al., 2008; Polka & Werker,1994). According to the Native Language Magnet theory, expanded (NLM-e) (Kuhl et al., 2008), infants store perceptual information of speech sounds during the early months of life, when production is still primitive and highly variable. This claim is supported in several neuroimaging studies that showed that the brains of bilingual adults do not show a native-like pattern of activity in response to a new language acquired past age 3 (Moore & Guan, 2001; Perani et al., 2003). Unlike native-like speech perception which is established very early in life, native-like speech production does not seem to establish until later. Studies have reported that, only around the ages of 5-7, children are able to produce all native sounds (Birdsong, 1999; Flege, 1991, 1995; Gildersleeve-Neumann et al., 2009; Long, 1993; Pallier et al., 1997; Strange, 1995) and, if a language is acquired after this period, foreign accent becomes evident (Flege, 1992). Nevertheless, whether both native-like speech perception and native-like speech production maintain throughout life once they are established is a question yet to be answered. Several studies have shown that speech production is very malleable and thus even adults experience L1 phonetic drift due to influence from the L2. For instance, Major (1992) found that adult speakers of American English who arrived in Brazil after the age of 22 and lived there for more than 12 years produced English /p, t, k/ with shorter voice onset time (VOT) than monolingual native

speakers of American English. Similarly, Chang (2010) found that over time English late L2 learners of Korean produced English /p, t, k/ with increased VOT and the following vowel with higher f0, similar to Korean aspirated stops /p^h, t^h, k^h/. Until now, no studies have found whether L1 phonetic drift also occurs in speech perception.

Although heritage speakers usually acquire the heritage language from their parents as their L1 and communicate in the heritage language at home, they do not use the heritage language extensively outside of familial settings. In a large scale survey of more than 14,000 Hispanic adults, Hakimzadeh and Cohn (2007) reported that, for first generation Hispanic immigrants who were born outside of the US (i.e., parents of heritage speakers), Spanish is the pervasive language used at home, while their US-born children (i.e., heritage speakers) are much more likely to speak English than Spanish, even if they are native bilinguals of English and Spanish. This implies that heritage speakers hear the heritage language more frequently than they speak it. The asymmetry in the use of the heritage language may lead to a discrepancy between heritage speakers' listening comprehension and speaking skills in the heritage language and, at the phonetic level, to a discrepancy between heritage language speech perception and production skills. In a study on Spanish heritage speakers' perception and production of Spanish stop consonants, Kim (2012) found that when perceiving minimal pairs of word-initial voiced and voiceless stop consonants (e.g., *beso* 'kiss' vs. *peso* 'weight') of varying degrees of VOT, heritage speakers did not differ from native Spanish speakers, whereas they did in their production. Heritage speakers produced Spanish /b, d, g/ with less prevoicing and produced Spanish /p, t, k/ with shorter VOT than native Spanish speakers, most likely to maintain the contrast between short-lag Spanish /p, t, k/ and long-lag English /p, t, k/. This finding implies that language dominance may have a larger effect on heritage speakers' production than their perception.

3. Lexical stress in Spanish and English

Spanish and English are typologically similar in that stress is phonologically contrastive in both languages. That is, it is possible to obtain words with different meanings solely by altering the position of stress (e.g., *papa* /ˈpa.pa/ 'potato' vs. *papá* /pa.ˈpa/ 'dad') (Hualde, 2005). Acoustically, stress is characterized as prominence in a syllable resulting from extra muscular energy that manifests in higher pitch, longer duration, and higher intensity (Ladefoged, 2001). Although researchers agree that these three universal parameters are important indices of lexical stress, there is disagreement over the relative strength of these cues. Such disagreement mostly has its roots in measuring lexical stress in different contexts, which results in confounding lexical stress with other prosodic factors such as pitch accent or prosodic boundary adjacency (Kim, 2011). With regard to lexical stress in Spanish, previously it has been argued that pitch (f0) is the primary cue in identifying stressed syllables in Spanish (Quilis, 1971, 1981; Enríquez et al., 1989; Llisterri et al., 2003). However, recent studies have shown that this is simply the result of lexical stress covarying with pitch accent, because usually the target words appeared either in isolation or in short carrier sentences with declarative intonation, in which the stressed syllable also carried a pitch accent. Ortega-Llebaria and Prieto (2007) examined utterances that were produced either in a declarative sentence, in which the stressed syllable also carried a pitch accent (e.g., *Determino la masa*. 'I determine the mass.'), or in a parenthetical sentence, in which there was no pitch accent in the stressed syllable (e.g., *La masa del átomo es medible – determino complacida*. 'The atom mass is measurable – I determine pleased.'). Results showed that there was an increase in the f0 in declarative sentences, while in parenthetical sentences, there was no variation in pitch. This suggests that when pitch accent is controlled, the f0 no longer functions as a robust cue to lexical stress. Thus, in a subsequent study, Ortega-Llebaria and Prieto (2009) investigated which of the two remaining acoustic correlates (i.e., intensity and duration) functions as the primary cue in the identification of lexical stress. Ortega-Llebaria and Prieto (2009) found that Spanish listeners detected stress contrasts when the duration was manipulated, but, with regard to intensity, they were only sensitive to changes in overall intensity, while ignoring any changes in spectral tilt. Therefore, among the three acoustic correlates, duration is considered to be the most consistent cue to lexical stress in Spanish. That is, stressed syllables are produced with longer duration than unstressed syllables regardless of whether they are accented or not (Ortega-Llebaria, 2006; Ortega-Llebaria & Prieto, 2007, 2009).

With regard to the correlates of lexical stress in American English, Sluijter and van Heuven (1996a, 1996b) found that in an unaccented context, stressed syllables were produced longer than their

unstressed counterparts, while the f0 and overall intensity had little or no cue-value in this context. This finding suggests that duration is the most important acoustic cue to stress in English as well. However, in contrast to the claims of Sluijter and van Heuven (1996a, 1996b), Beckman and colleagues (Beckman & Edwards, 1994; Campbell & Beckman, 1997) posit that the difference between stressed and unstressed syllables is primarily one of vowel quality, and other acoustic properties such as duration and intensity are artifacts of vowel reduction. For instance, a full vowel [ɑ], will be much longer than its reduced counterpart, because it requires a more open vocal tract, lower jaw, and larger lip displacement (Beckman & Edwards, 1994). Thus, in order to factor out the effect of vowel reduction, Campbell and Beckman (1997) compared full vowels [æ], [i], and [u] in stressed and in unstressed conditions (e.g., *B**a**ddle* vs. *B**a**dd-Ellis*). The results showed that stressed syllables were longer and had greater energy in high frequency regions only in the accented condition; in the unaccented condition, speakers varied in their use of duration and spectral tilt. Thus, in the absence of pitch accent, it is the vowel quality that functions as the decisive marker in identifying lexical stress in English, and changes in duration and spectral tilt depend on the presence of vowel reduction. Unlike English in which unstressed vowels tend to reduce to a schwa [ə] (e.g., *banana* [bə.ˈnæ.nə]), vowel reduction is not a phonological phenomenon in Spanish and thus vowel quality is maintained in both stressed and unstressed syllables (e.g., *banana* [ba.ˈna.na]) (Hualde, 2005; Quilis & Esgueva, 1983).[2] Thus, English L2 learners of Spanish are found have difficulty identifying stressed syllables in Spanish when duration is the only cue available in the speech signal, whereas native Spanish speakers are sensitive to even small differences in this cue (Ortega-Llebaria et al., 2013).

Apart from vowel quality, there are important differences between Spanish and English regarding the role of stress. In English, words that contrast in stress position (i.e., stress minimal pairs), such as *cónduct* and *condúct*, are always related in meaning and the difference only lies in grammatical categories (i.e., noun vs. verb) on a very limited basis (Saalfeld, 2009). While nouns typically have stress on the left (e.g., *cónduct*), verbs have it on the right (e.g., *condúct*) (Jensen, 1993). Since stress minimal pairs in English pertain to different grammatical categories, listeners can recover information from the context even if the lexical stress is placed in the wrong position. For instance, if a listener hears **The CEO must cónsult with the board of directors prior to taking action*, he will understand **cónsult* as a verb, not as a noun, based on the location of the word within the sentence (Cutler, 1986). In Spanish, however, stress minimal pairs occur both within the same grammatical category (e.g., *pápa* 'pope' vs. *papá* 'dad') and across different grammatical categories (e.g., *ámo* 'master' vs. *amó* 'he loved'), and there is not necessarily a relationship in meaning (Saalfeld, 2009). For verbs like *háblo* 'I speak' and *habló* 'he/she spoke', although they belong to the same verb (i.e., *hablar* 'to speak'), they differ in grammatical properties such as person (i.e., "yo" vs. "él/ella/Ud."), tense (i.e., present vs. past), etc. In this case, listeners would have to pay attention to the position of lexical stress in order to understand the message, since there might not be any other cues that indicate these grammatical properties. For example, if a listener hears **Háble con el director* 'I spoke with the director', unless more information is retrievable in the context, he will incorrectly understand this sentence as *Háble con el director.* '(You) Talk with the director' (Saalfeld, 2009). Due to the differences between the stress systems in the two languages, Cutler (1986) argued that English listeners do not effectively use stress cues in the speech signal when understanding the message. Saalfeld (2009) supports this view in her study of English L2 learners of Spanish, in which she found that English L2 learners of Spanish have great difficulty in identifying the position of lexical stress in Spanish even after explicit instruction.

4. Research questions and predictions

The present study examines (1) whether English-dominant Spanish heritage speakers have difficulty in perceiving stress contrasts in Spanish like English L2 learners of Spanish do, given that English is the dominant language for both groups. For instance, Dupoux et al. (2010) and Peperkamp

[2] Vowel reduction has been found in certain dialects of Spanish such as Mexican Spanish (Boyd-Bowman, 1952; Canellada & Zamora Vicente, 1960; Lope Blanch, 1963), and Andean Spanish (Delforge 2008, Lipski 1990,). However, given that in Spanish vowel reduction is a variable phenomenon that does not occur systematically across all speakers of the dialect as is the case in English and given that neither vowel loss nor vowel reduction was found in the monolingual data of the present study, we will not discuss this matter further.

et al. (1999) investigated the perception of Spanish lexical stress by French-Spanish simultaneous bilinguals (i.e., one parent is a native French speaker and the other parent is a native Spanish speaker) and found that some French-Spanish simultaneous bilinguals performed like Spanish monolingual native speakers, while others performed like French late L2 learners of Spanish. According to the correlation analyses, bilinguals' performance was correlated with their early language exposure. Although the target population of the present study is Spanish heritage speakers who are early sequential bilinguals of Spanish (L1) and English (L2) and whose parents are both native Spanish speakers, given that they are bon in the US and have been exposed to Spanish from birth, it is expected that they will show target-like performance in their perception of Spanish lexical stress. Apart from their perception, the present study also investigates (2) whether Spanish heritage speakers successfully distinguish Spanish stress minimal pairs in their production. Given that speech production is malleable and thus it is more likely to be affected by cross-linguistic transfer than speech perception, it is expected that Spanish heritage speakers, who use English (i.e., majority language) more frequently than Spanish (i.e., minority language), will show less target-like behavior when producing Spanish lexical stress.

5. Experiment 1: Perception test

5.1. Participants

In total, 25 monolingual native speakers of Spanish (18 F, 7 M) (avg. age: 25.4 years), 11 Spanish heritage speakers (8 F, 3M) (avg. age: 20 years), and 47 English L2 learners of Spanish (36 F, 11 M) (avg. age: 19.36 years) participated in the study. The focus group of the study, the heritage speakers (HSs), were all born and raised in the US, mostly in the Chicago area, to Mexican families.[3] Based on three factors, (1) the age of acquisition of Spanish and English, (2) language use, and (3) language proficiency, we determined that the HSs were all English-dominant. That is, all the HSs were early bilinguals in that they acquired both Spanish and English before the age of 5, which is considered to be the critical age for native-like pronunciation (Flege, 1992), and currently use English (78.64%) far more frequently than Spanish (21.36%). They reported that although they use Spanish with their parents, siblings, and other Spanish-speaking friends, it is limited mostly to their parents. The HSs also reported that even when communicating with their parents, their parents speak to them in Spanish far more frequently than they speak to their parents, which supports Hakimzadeh and Cohn (2007). With regard to the overall language proficiency, on a five-point Likert scale (5 being native-like and 1 being poor), the HSs self-rated their proficiency in Spanish (avg. 3.78 out of 5) lower than their English (avg. 4.85 out of 5). HSs' performance was compared to that of monolingual native speakers of Spanish (NSs) (i.e., control group) in order to determine whether they show a target-like behavior. The NSs were recruited in Santiago de Querétaro, Mexico.[4] The NSs reported that they did not learn languages other than Spanish until later in life and use Spanish almost all of the time (89.7%). Although they speak languages other than Spanish, the present study will consider them as monolingual native speakers, because they do not use the other languages functionally. HSs' performance was also compared to that of English L2 learners of Spanish (L2s) to examine whether HSs' possible non-target-like behavior is due to influence from English (i.e., their dominant language).

[3] With the exception of one HS whose father was from Colombia (and mother from Mexico), all the parents of the HSs immigrated to the US as adults from different areas in Mexico, primarily from the central-west region of the country (i.e., Durango, San Luis Potosí, Zacatecas, Jalisco, and Michoacán). There may be a correlation between HSs' performance and the region where the parents are from, similar to Peperkamp et al. (1999) who found a correlation between bilinguals' performance and their father's country of origin. However, since no study has been found on cross-dialectal differences in the use of Spanish lexical stress in Mexico, the present study did not divide the heritage speakers into sub-groups.

[4] Santiago de Querétaro is the capital of the state of Querétaro located in the central region of Mexico. Due to the expansion of industry and close proximity to Mexico City, Santiago de Querétaro has experienced a massive influx from surrounding states such as the State of Mexico, Guanajuato, San Luis Potosí, and Michoacán ("Aumenta migración", 2011). Moreover, because the crime rate in northern states of Mexico has risen significantly, there has been a "silent migration" from northern states as well such as Durango and Chihuahua (Arreola, 2011). Given that the HSs in the present study have their roots in different areas of Mexico, mostly from the central-west region, the NSs from Santiago de Querétaro were considered to be an appropriate control group.

5.2. Test materials

28 stress minimal pairs that differ only in verbal inflection were used in the present study. The stress minimal pairs consisted of disyllabic Spanish regular *–ar* verbs in the first person singular of the present indicative (e.g., *paso* 'I pass') and the same verbs in the third person singular in the (simple) past perfective tense (e.g., *pasó* 'he/she passed'). The former case (henceforth, *páso*-type words) always had stress on the first syllable and the latter case (henceforth, *pasó*-type words) always had it on the last syllable. Only verbs with one of the three cardinal vowels /a, i, u/ in the stem were included in the study. Half of the stress minimal pairs had the low vowel /a/ (e.g., *p**a**sar* 'to pass') and the other half had high vowels /i/ and /u/ (e.g., *c**i**tar* 'to cite' and *d**u**dar* 'to doubt'). The minimal stress pairs were matched in frequency using the LEXESP corpus (Sebastián-Gallés, et al., 2000) to avoid possible bias toward a certain form that is more frequent. Apart from the target stress minimal pairs, 32 verbs that do not form stress minimal pairs in the present indicative and the past perfective tense were used as fillers in order to disguise the purpose of the study and to confirm that the participants were able to successfully conjugate Spanish verbs. This way any non-target-like behavior found in the target words would not be confounded with possible problems in verb conjugation. All the verbs, both the target words and the fillers, were embedded in meaningful sentences with the same structure, where the embedded verbs always fell in the second-to-last position, followed by a subject (e.g., *Por la plaza "paso" yo*. 'Through the square, I passed'.). The sentences did not include any information that cued a particular tense (see Appendix). Unlike in English, in which the word order is relatively fixed, Spanish has greater syntactic freedom and items indicating new information are generally moved to the end of the sentence, in which they receive the nuclear stress. Thus, by placing the subject in the last position, the nuclear stress fell on the subject, not on the target word. The purpose of this measure was to avoid the target word carrying the pitch accent and to make sure that duration was used as the primary cue to stress. The stimuli were produced by a male native speaker of Mexican Spanish from Durango, Mexico.[5] The productions were audio-recorded in a sound-attenuated booth using an AKG C520 head-mounted microphone and a Marantz PMD570 solid state recorder. The last word of each sentence (i.e., the subject) was removed, leaving the sentences incomplete (e.g., *Por la plaza paso…*). Since transitions occurred from a back vowel /o/ (i.e., low F2) to either a front vowel /e/ (i.e., *él* "he") or a voiced palatal approximant /j/ (i.e., *yo* "I")[6] (i.e., high F2), the cut-off point was determined as the moment when the F2 started to increase (see Figure 1). After removing the subjects, all the tokens were played to make sure no transition information of the subject was included in the speech signal.

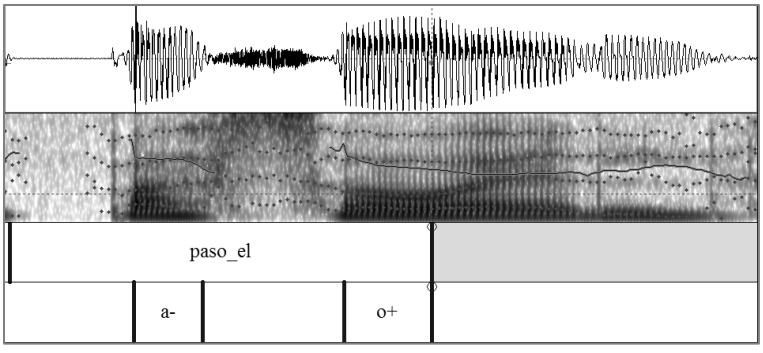

Figure 1. Cut-off point of the target word

[5] The native Spanish speaker (age: late 30s) was born and raised in Durango, Mexico, and only arrived to the US for his graduate studies. He has lived in the US for more than 10 years, because of which it is possible that his Spanish pronunciation has been affected by English. However, no noticeable foreign accent was perceived in his Spanish according to the researcher and several native Spanish speakers.

[6] There were some cases, in which *yo* was produced with varying degrees of occlusion between voiced palatal approximant [ʲ] and voiced palatal stop [ɟ], which has been found in Mexican Spanish (Martín-Butragueño, 2002). Even in such cases, the same criterion was used to remove transition information from the following segment.

5.3. Procedures

A forced-choice identification task was conducted for the perception test. Two lists were created, each with one of the stress minimal pairs (e.g. List A: *páso* and *sacó*, List B: *pasó* and *sáco*). The participants were assigned to one of the two lists. This way they were exposed to only one of the stress minimal pairs. This measure was taken to avoid a possible priming effect, because if both stress patterns of the same verb were in the same list, listening to one stress pattern may affect the perception of the other stress pattern that appears after. The participants sat in front of a computer and listened to the incomplete sentences through headphones. In both locations (i.e., the US and Mexico), the experiment was conducted in a phonetics laboratory equipped with a sound-attenuated booth and audio recording devices. In Mexico, the stimuli were presented through a Dell Vostro 230 desktop computer with KOSS UR-20 headphones and, in the US, they were presented through a Samsung SENS R410 laptop computer with Sony MDR 7506 headphones. Before the initiation of the experiment, the participants were informed that they would listen to Spanish sentences, in which the subjects always appeared after the verbs. Some sample sentences, which were not used in the experiment, were provided for a better understanding of the sentence structure. The participants were also told that the last word of each sentence (i.e., the subject) had been cut off and that their task was to identify the last word by choosing one of the two options that were indicated on each side of the computer screen (e.g., *yo* "I" on the left side vs. *él* "he" on the right side) and click on either the left or the right key of the keyboard. The order of the options was counter-balanced. The correct answers were automatically coded as "1" and the incorrect answers were coded as "0". All responses were collected through E-Prime, a software program for psychology experiments.

5.4. Results

Figure 2 shows the accuracy rate of *páso*-type words, *pasó*-type words, and fillers of the NSs, the HSs, and the L2s. The near-ceiling accuracy rates for the fillers in all three groups indicate that the errors that occurred in the experiment are not due to problems regarding verb conjugation. The effects of group (NS/HS/L2), stress pattern (*páso*-type words/*pasó*-type words), and the interaction of the two fixed factors on participants' response accuracy (correct/incorrect) were statistically analyzed using logit mixed effects modeling with subject and item as random factors. The *glmer* function in the *lme4* package in R (Baayen, 2008) was used for the analysis. Results showed that the NSs (the baseline group) performed significantly better than the L2s ($\beta = -0.6979$, $z = -2.135$, $p < 0.05$), while the difference between the NSs and the HSs was not significant. A significant main effect of stress pattern was found ($\beta = 2.1012$, $z = 3.455$, $p < 0.001$), which indicates that overall the accuracy rate for the *páso*-type words (the baseline stress pattern) was lower than the *pasó*-type words. With regard to the interaction between group and stress pattern, a significant interaction was found between L2 and stress pattern ($\beta = -4.3293$, $z = -6.257$, $p < 0.001$), while the interaction between HS and stress pattern did not reach statistical significance. This suggests that while the difference between the accuracy rate for the *páso*-type words and that for the *pasó*-type words was similar between the HSs and the NSs, the difference between the accuracy rates of the two stress patterns was significantly smaller for the L2s than for the NSs, due to the opposite patterns that these two groups showed with regard to this value (NS: positive, L2: negative). Figure 2 clearly shows that, while the accuracy rate of the NSs and the HSs for the *pasó*-type words was slightly higher than that for the *páso*-type words, for the L2s, the accuracy rate for the *páso*-type words was considerably higher. Pairwise comparisons of group and stress pattern were conducted using the *lsmeans* function in the *lsmeans* package in R (Baayen, 2008). Results showed that the difference between accuracy rates for the two stress patterns was statistically significant for the NSs ($p < 0.01$) and the L2s ($p < 0.001$) and reached close to significance level for the HSs ($p = 0.059$). When comparing the accuracy rates for each stress pattern across the three groups, the L2s had significantly lower accuracy rates for the *pasó*-type words than the NSs ($p < 0.001$) and the HSs ($p < 0.001$), while their accuracy rates for the *páso*-type words were not significantly different from the other two groups. The NSs and the HSs did not significantly differ from each other in any of the two stress patterns.

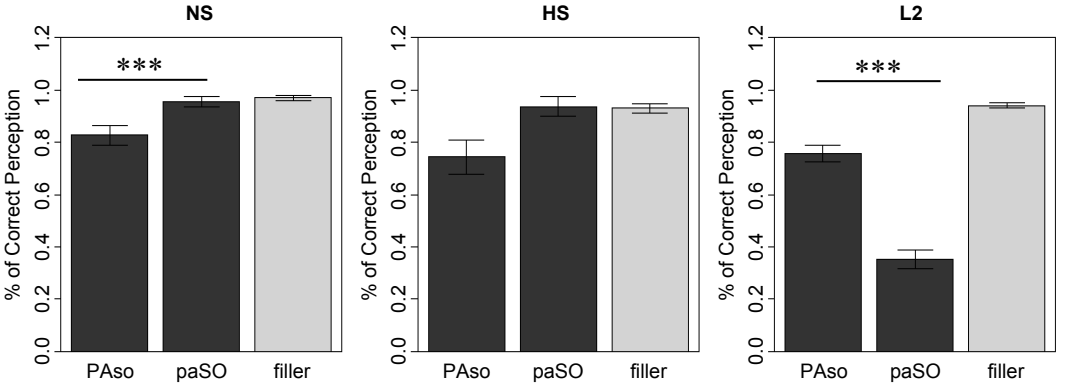

Figure 2. Accuracy rates for *páso*-type words (PAso), *pasó*-type words (paSO), and fillers of monolingual native speakers (NS), heritage speakers (HS), and L2 learners (L2) (***: $p < 0.001$)

5.5. Discussion

The findings of the perception task indicate that the HSs performed similarly to the NSs when perceiving Spanish lexical stress. Both groups showed a similar pattern in that they performed better when listening to the *pasó*-type words than when listening to the *páso*-type words and no significant difference was found between the accuracy rates of the two groups. The L2s, on the other hand, differed from the other two groups not only quantitatively (i.e., their overall accuracy rates were significantly lower), but also qualitatively, in that they showed a different pattern from the other two groups. That is, they performed significantly better when listening to the *páso*-type words than when listening to the *pasó*-type words. Further analysis with pairwise comparisons showed that the main difference between the L2s and the other two groups is derived from L2s' low accuracy rate for the *pasó*-type words. Unlike the NSs and the HSs whose performance for the *pasó*-type words approached ceiling level (avg. 95.5% and avg. 93.75%, respectively), L2s' accuracy rate for this stress pattern was lower than chance level (avg. 35.24%). Given that L2s' accuracy rate for the *páso*-type words was significantly above chance level (avg. 75.66%), similar to those of the NSs and the HSs, it is likely that the L2s had a bias toward selecting the *páso*-type words. Therefore, participants' sensitivity and response bias toward the *páso*-type words were analyzed by calculating their d-prime scores and response criterion (C scores), respectively. HIT was considered as the case in which the participants selected a *páso*-type word when the stimulus was a *páso*-type word and FALSE ALARM was considered as the case in which the participants selected a *páso*-type word when the stimulus was a *pasó*-type word. As shown in Figure 3, L2s' d-prime score and C score were noticeably different from those of the NSs and the HSs. The L2s' d-prime score was close to zero, which indicates that they had extremely low sensitivity in distinguishing the two stress patterns and their negative C score (i.e., liberal response bias) confirms that this low sensitivity is due to having bias toward selecting the *páso*-type words. Two sets of one-way ANOVA with group as the independent variable were conducted on the participants' d-prime scores and C scores. Results showed that there was a main effect of group in both cases (d-prime score: $F(2,80) = 84.2$, $p < 0.001$; C score: $F(2, 80) = 30.33$, $p < 0.001$). Tukey HSD post-hoc analyses confirm that while the HSs did not differ from the NSs, the L2s differed from the other two groups in both scores ($p < 0.001$ in all cases).

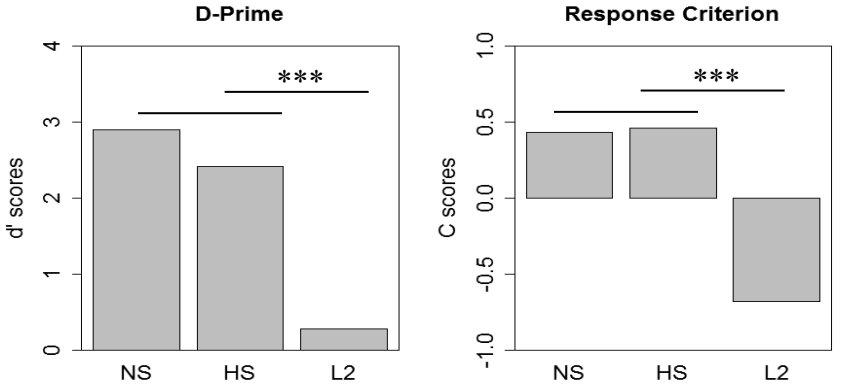

Figure 3. D-prime (sensitivity) and response criterion (response bias) scores of monolingual native speakers (NS), heritage speakers (HS), and L2 learners (L2) (***: $p < 0.001$)

Given that all the participants listened to the same stimuli, the different patterns found in the three groups can be explained by how they attended to the acoustic information of the stimuli. Therefore, the critical acoustic cues of Spanish and English, i.e., duration and vowel quality of the stressed and unstressed vowels, respectively, were analyzed. Figure 4 shows the durational differences between stressed and unstressed vowels for the *páso*-type words and the *pasó*-type words. The durational differences were calculated by subtracting the duration of the unstressed vowel from the duration of the stressed vowel in each item. If the stressed vowel was longer than the unstressed vowel, the value was higher than zero, and if the stressed vowel was shorter than the unstressed vowel, its value was lower than zero. As shown in Figure 4, the durational differences between stressed and unstressed vowels were in general slightly higher than zero for the *páso*-type words, while for the *pasó*-type words the differences were much higher than zero. The effect of stress pattern on durational differences was analyzed using liner mixed effects modeling with item as a random factor. Results showed that there was a significant effect of stress pattern ($\beta = 60.747$, $t = 5.464$[7]). That is, the durational differences were significantly larger for the *pasó*-type words than for the *páso*-type words. Thus, the finding that the NSs and the HSs had higher accuracy rate for the *pasó*-type words suggests that it is likely that they attended to this cue when listening to the stimuli. However, despite the larger durational differences in this stress pattern, the L2s were not able to correctly perceive the location of lexical stress in 64.76% of the cases. This finding suggests that L2s did not effectively utilize the durational cue when identifying the location of stress in Spanish, but rather had bias toward selecting the *páso*-type words as attested in the low d-prime score (i.e., low sensitivity) and negative C score (i.e., liberal bias toward *páso*-type words).

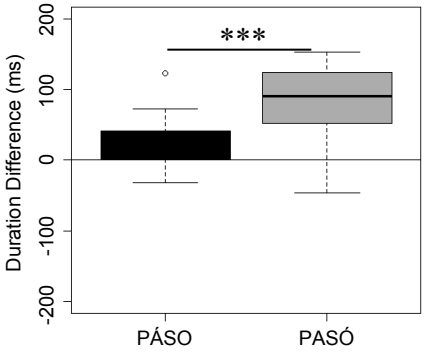

Figure 4. Durational differences between stressed and unstressed vowels for *páso*-type words and *pasó*-type words of the stimuli (***: $p < 0.001$)

[7] Following Baayen (2008), t-values higher than 2 were considered as statistically significant.

To account for possible inherent differences in duration across vowels (Peterson & Lehiste, 1960), further analysis was conducted to compare the duration of analogous vowels across minimal pairs (e.g., stressed /a/ in *paso* vs. unstressed /a/ in *pasó*) (see Figure 5). Given that each word was produced with a different duration, vowel duration was normalized by calculating the ratio of the duration of each vowel to the duration of the entire word. The effects of vowel (/a, i, o, u/[8]), stress (stressed/unstressed), and the interaction of the two fixed factors on duration ratio were analyzed using linear mixed effects modeling with item as a random factor. Results showed that there was a significant main effect of vowel, which indicates that there were inherent durational differences among the vowels. /a/ (the baseline vowel) was in general longer than /i/ (β = -0.07671, t = -2.805), but shorter than /o/ (β = 0.06523, t = 3.174). No difference was found between /a/ and /u/. Moreover, there was a significant main effect of stress (β = -0.09179, t = -3.960), but no significant interaction between vowel and stress. That is, the stressed vowels (the baseline condition) were overall longer than the unstressed counterparts and this pattern is consistent across vowels. However, pairwise comparisons of vowel and stress using the *lsmeans* function in the *lsmeans* package in R (Baayen, 2008) showed that the difference was statistically significant only for /a/ and /o/ and not for /i/ and /u/. This indicates that durational differences are not maintained to the same degree across all vowels.

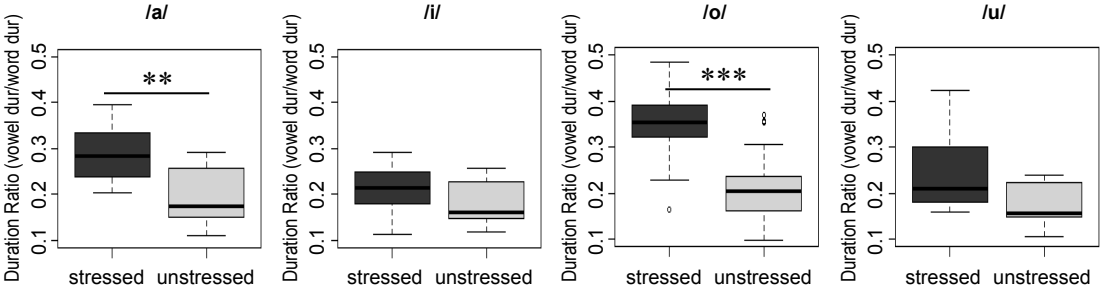

Figure 5. Duration ratio between stressed and unstressed vowels of the stimuli
(***: $p < 0.001$, **: $p < 0.01$)

Regarding vowel quality, which is considered to be a critical stress cue in English, but not in Spanish, the formant information (i.e., F1 and F2) of the stressed and unstressed vowels was extracted using a script in *Praat* (Boersma & Weenink, 2005) (see Figure 6). Formant values that were anomalously higher/lower than the expected values following Quilis and Esgueva (1983) were individually reviewed and manually adjusted when the formant tracking was not consistent with the actual formants shown in the spectrograms. In total, 39 formant values were adjusted, mostly for the F2 of the back vowels /o, u/ (36 cases out of 39). In these cases, the extracted F2 values were above 2,000 Hz, which were substantially higher than the expected values from Quilis and Esgueva (1983) (i.e., /o/: 884.8 Hz, /u/: 669.08 Hz). Given that both vowels have low F1 and F2 values (i.e., they usually appear very close to each other in the spectrogram), there were many cases in which the formant tracking did not recognize them as two separate formants, but rather grouped them as one, and erroneously extracted this value as the F1. Consequently the value that was supposed to be the F3 was extracted as the F2. The effects of vowel (/a, i, o, u/), stress (stressed/unstressed), and the interaction between the two fixed factors on the F1 and the F2 values were analyzed using linear mixed effects modeling with item as a random factor. Results showed that there was a significant main effect of vowel in both the F1 and the F2, which indicates that overall the F1 and the F2 of the vowel /a/ (the baseline vowel) were significantly different from the other vowels. With regard to the F1, there was also a significant main effect of stress (β = -36.52, SE = 15.26, t = -2.39), suggesting that in general the stressed vowels (the baseline condition) had higher F1 values than the unstressed counterparts. However, the significant interaction found between stress and /o/ (β = -58.72, SE = 19.89, t = -2.95) indicates that the main effect of stress is mostly due to /o/. Significant interaction was not found between stress and the other vowels. Pairwise comparisons of vowel and stress confirm that /o/ was the only vowel that showed significantly different F1 values between stressed and unstressed vowels ($p <$

[8] The vowels consisted of /a, i, u/ in the stem and the inflectional morpheme /o/.

0.001), while the other three vowels did not. Regarding the F2, no main effect or significant interaction was found. The findings showed that while /a, i, u/ were produced as expected, conforming to the Spanish phonological rule (i.e., no phonological vowel reduction), /o/ was significantly reduced in the unstressed condition. However, it is unconvincing that vowel reduction occurred only in /o/ and not in the other vowels, because while the phonetic contexts were consistent across stressed and unstressed conditions for /a, i, u/, /o/ was followed by a different word depending on the stress pattern (i.e., *páso*-type words: before *yo* 'I', *pasó*-type words: before *él* 'he'). Given that the voiced palatal approximant /j/ (from *yo*) has lower F1 than the mid front vowel /e/ (from *él*), it is likely that /j/ (i.e., low F1) is responsible for the lowering of the F1 of /o/ in the unstressed condition. Therefore, /o/ was removed from the analysis. When considering only /a, i, u/, the main effect of stress on F1 was no longer maintained and no significant interaction was found between vowel and stress.

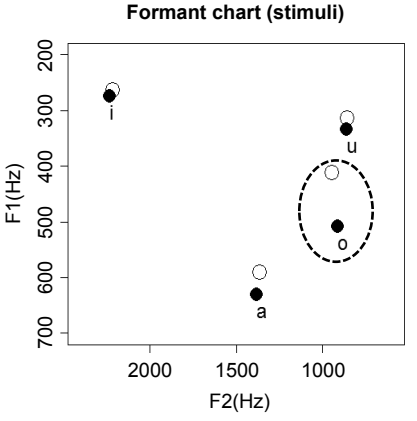

Figure 6. F1-F2 vowel plot of stressed (filled circle) and unstressed vowels (unfilled circle) of the stimuli (only the vowel pair in the dotted circle had significantly different F1 and F2 values)

The findings from the analyses of the stimuli are consistent with the acoustic characteristics of Spanish stressed and unstressed vowels that have been reported in the literature. The stressed and unstressed vowels of the stimuli were distinguished based on duration, not vowel quality, as would have been the case in English. The stressed vowels were longer than the unstressed vowels both within the same word (e.g., /a/ vs. /o/ in *páso*) and across minimal pairs (e.g., /a/ in *paso* vs. /a/ in *pasó*). Moreover, different patterns were found between the *páso*-type words and the *pasó*-type words when comparing stressed and unstressed vowels within the same word. While the stressed vowels were slightly (but statistically significantly) longer than the unstressed vowels for the *páso*-type words, for the *pasó*-type words the durational differences between the stressed and unstressed vowels were considerably large. This may account for the reason the NSs and HSs had higher accuracy rates for the *pasó*-type words than for the *páso*-type words, while this pattern was not shown for the L2s. It is plausible that while both the NSs and the HSs attended to the acoustic information of the stimuli, most likely the durational differences between stressed and unstressed vowels, the L2s did not. Instead, we argue that the L2s had a bias toward the *páso*-type words, possibly because this is the verbal form that is first learned in the classroom (i.e., the present tense), hence the form that they are more familiar with.

6. Experiment 2: Production task

6.1. Participants

Among the 83 subjects that participated in the perception task, 10 NSs (6 F, 4 M), 11 HSs (8 F, 3 M), and 12 L2s (8 F, 4 M)[9] participated in the production task.

[9] Due to some irrecoverable technical problems (e.g., missing files, malfunction of recording devices), idiosyncratic speech styles that are problematic for acoustic analysis (e.g., disfluency, creaky voice), and time constraint, out of the 47 L2s only the production data of 12 L2s were considered in the analyses.

6.2. Test materials and procedures

Each participant read out loud the same sentences used in the perception task. All the sentences were presented on PowerPoint slides on a computer screen with the subject of each sentence (i.e., the last word) highlighted in a different color. As in the perception task, the participants were informed that the subjects always appeared at the end of the sentences after the verbs and they were instructed to produce the highlighted subjects with more prominence. In both the US and Mexico, the productions were recorded in a sound-attenuating booth. In the US, the recordings were collected using an AKG C520 head-mounted microphone and a Marantz PMD570 solid state recorder. In Mexico, the recordings were collected using an Olympus ME-31 compact gun microphone and an Olympus LS-11 linear PCM recorder. Following the same criterion as in Section 5.2., the cut-off point between the target word and the last word (i.e., the subject) was determined as the moment when the F2 value started to increase.

6.3. Results

Given that duration is considered as a critical cue to lexical stress in Spanish (Ortega-Llebaria, 2006; Ortega-Llebaria & Prieto, 2007, 2009), whereas in English it is vowel quality (Beckman & Edwads, 1994; Campbell and Beckman, 1997), participants' durational differences between stressed and unstressed vowels within the same word (e.g., /a/ and /o/ in *páso* and *pasó*), across minimal pairs (e.g., stressed /a/ in *páso* vs. unstressed /a/ in *pasó*), and the vowel quality of stressed and unstressed vowels across minimal pairs were measured and statistically analyzed.[10] Tokens that were produced with creaky voice, before/after a pause, or with unclear articulation were excluded from the analyses. Out of 1848 target tokens, 358 tokens (NS: 36, HS: 41, L2: 281) were excluded.

6.3.1. Duration

The durational differences were calculated using the same method as in Section 5.5. Figure 7 shows the durational differences between stressed and unstressed vowels for the *páso*-type words and the *pasó*-type words produced by the NSs, the HSs, and the L2s. The effects of group (NS/HS/L2), stress pattern (*páso*-type words/*pasó*-type words), and the interaction between the two fixed factors on the durational differences were analyzed using linear mixed effects modeling with subject and item as random factors. Results showed that there was a significant effect of stress pattern ($\beta = 0.01001$, $t = 2.053$), which suggests that the durational differences between stressed and unstressed vowels were in general larger for the *pasó*-type words than for the *páso*-type words (the baseline stress pattern). A significant group effect was found only for the L2s ($\beta = -0.011862$, $t = -2.389$), but not for the HSs. That is, L2s' overall durational differences were significantly smaller than those of the NSs (the baseline group), whereas HSs' overall durational differences did not differ from those of the NSs. However, although the HSs did not differ from the NSs in the overall durational differences, significant interaction was found between stress pattern and HS ($\beta = 0.038493$, $t = 8.654$), indicating that the difference between the durational differences for the *páso*-type words and those for the *pasó*-type words was larger for the HSs than for the NSs. A significant interaction between stress pattern and group was also found for the L2s ($\beta = 0.04793$, $t = 9.675$).

As seen in Figure 7, HSs' and L2s' durational differences for the *pasó*-type words were evidently larger than zero, similar to those of the NSs. This indicates that both the HSs and the L2s produced the stressed vowels with much longer duration than the unstressed vowels for this stress pattern. However, the results also showed that their durational differences for the *páso*-type words were not as large. In fact, in nearly half of the cases, HSs' and L2s' durational differences were smaller than zero, which is demonstrated in their median values that are close to zero (HS: 0.0071, L2: -0.007). That is, in nearly half of the cases, the HSs and the L2s produced the unstressed vowels longer than the stressed vowels. This was apparently different in the case of the NSs, because the NSs' durational differences for the *páso*-type words were in most cases higher than zero, similar to those for the *pasó*-type words.

[10] The present study also analyzed the pitch and amplitude, which are also considered as acoustic correlates of stress (Ladefoged, 2001). However, since no statistical difference was found between participants' stressed and unstressed vowels, the present study will not further discuss these cues.

Pairwise comparisons of group and stress pattern confirmed that NSs' durational differences for the *páso*-type words were larger than those for the HSs and the L2s ($p < 0.001$ in both cases). Moreover, while HSs' and L2s' durational differences for the *páso*-type words were significantly smaller than the durational differences for the *pasó*-type words ($p < 0.001$ in both cases), NSs' durational differences for the two stressed patterns were not significantly different.

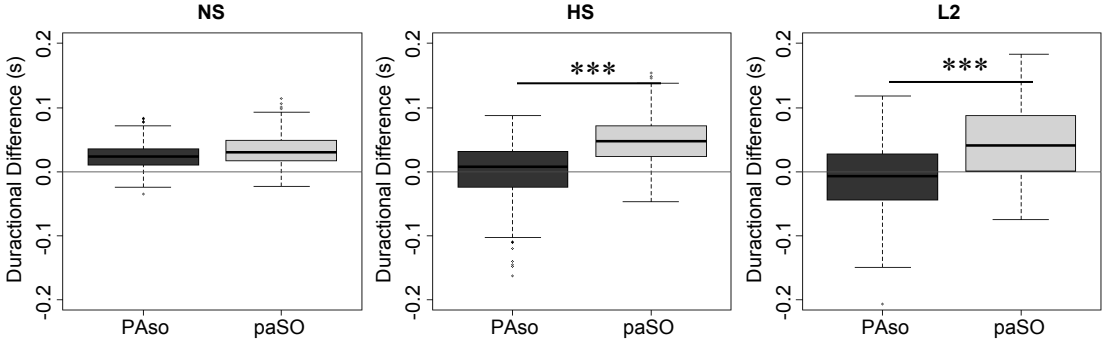

Figure 7. Duration differences between stressed and unstressed vowels for *páso*-type words and *pasó*-type words produced by monolingual native speakers (NS), heritage speakers (HS), and L2 learners (L2) (***: $p < 0.001$)

Vowel duration was further analyzed by comparing the duration of the same vowels across minimal pairs (e.g., stressed /a/ in *páso* vs. unstressed /a/ in *pasó*). Following the same method in Section 5.5, in order to control for differences in duration across words, vowel duration was normalized by calculating the ratio of the duration of each vowel to the duration of the entire word. The effects of group (NS/HS/L2), stress (stressed/unstressed), and the interaction between the two fixed factors on duration ratio were analyzed for each vowel (/a, i, o, u/) using linear mixed effects modeling with subject and item as random factors. Results showed that there was a significant main effect of stress for /a/ ($\beta = -0.0581$, $t = -2.981$), /o/ ($\beta = -0.1232$, $t = -5.152$), and /u/ ($\beta = -0.09158$, $t = -4.298$), but not for /i/. This indicates that stressed vowels (the baseline condition) were overall longer than unstressed vowels only for /a, o, u/, but the difference was not maintained for /i/, similar to what was found in Section 5.5. No significant effect of group was found for any of the vowels analyzed, which indicates that all the vowels were in general produced with similar duration across groups. However, with regard to /o/ and /u/, there was a significant interaction between stress and L2 (/o/: $\beta = 0.07987$, $t = 2.721$; /u/: $\beta = 0.0946$, $t = 2.250$), while in the other cases, no significant interaction was found. That is, when considering the durational differences between stressed and unstressed vowels, HSs' durational differences were not different from those of the NSs (the baseline group) for any of the vowels tested, while in the case of the L2s, their durational differences were larger than those of the NSs only for the back vowels /o/ and /u/. Pairwise comparisons of group and stress for /o/ and /u/ confirmed that the stressed vowels were significantly longer than their unstressed counterparts for both the NSs ($p < 0.001$ for both /o/ and /u/) and the HSs (/o/: $p < 0.01$, /u/: $p < 0.05$), while no significant difference was found between L2s' stressed /o/ and /u/ and their unstressed counterparts. Although no significant interaction was found between stress and either of the two non-baseline groups for /a/, the pairwise comparisons showed that only the NSs produced stressed /a/ longer than unstressed /a/.

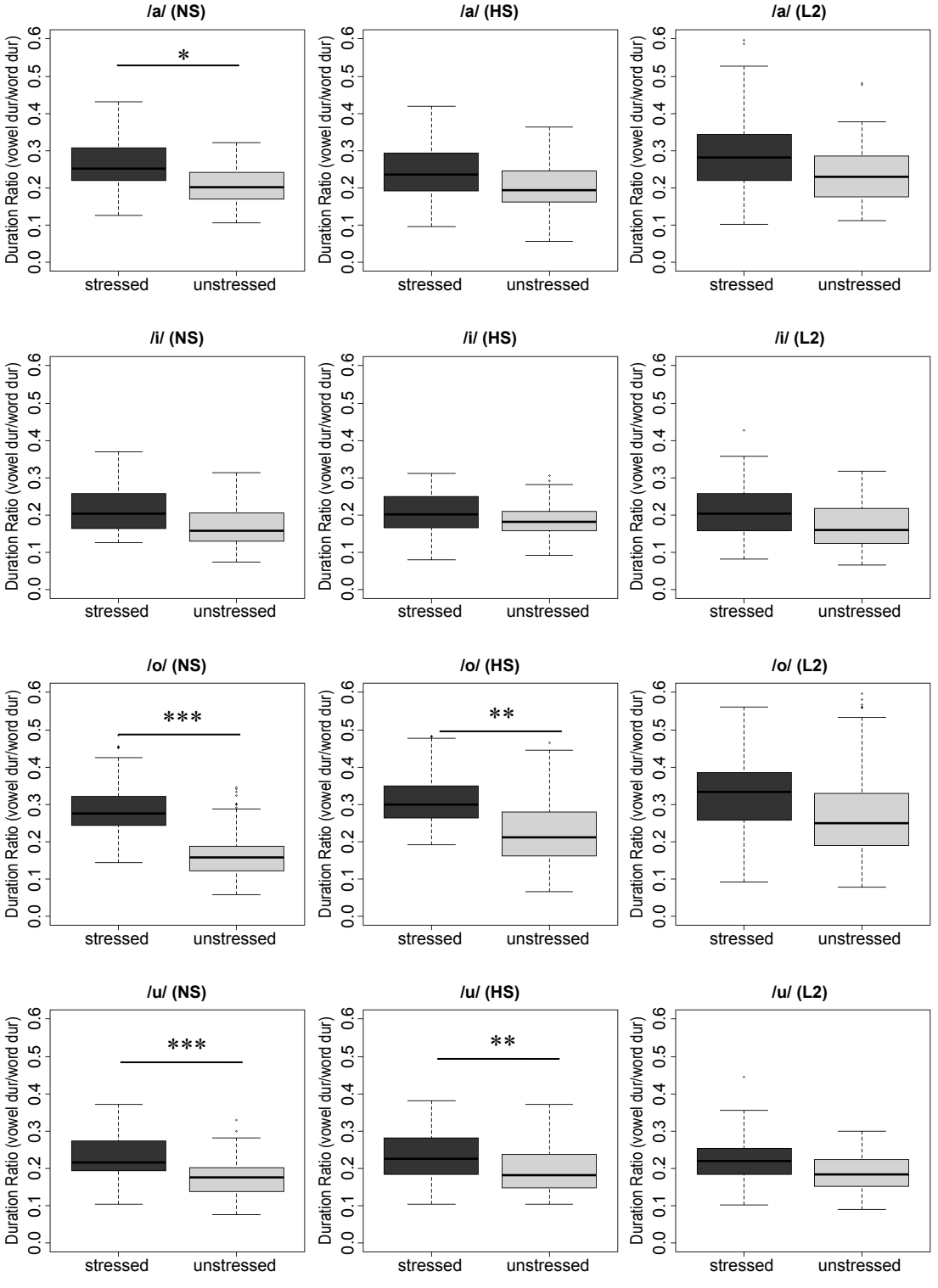

Figure 8. Duration ratio between stressed and unstressed vowels of monolingual native speakers (NS), heritage speakers (HS), and L2 learners (L2) in the vowels /a/, /i/, /o/, and /u/
(***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$)

6.3.2. Vowel quality

For vowel quality, the values of the first two formants (i.e., F1 and F2) of stressed and unstressed vowels were extracted. As in Section 5.5, formant values that were anomalously higher/lower than the expected values from Quilis and Esgueva (1983) were individually reviewed and manually adjusted when the formant tracking was not consistent with the actual formants shown in the spectrograms. In total, 163 formant values were adjusted, mostly for the F2 of the back vowels /o, u/ (107 cases out of 163) (similar to Section 5.5). In order to control for physiological differences resulting from individual differences in vocal tract length, sex, age, etc., the raw formant values were normalized using Lobanov's (1971) z-score procedure. The effects of group (NS/HS/L2), stress (stressed/unstressed), and the interaction between the two fixed factors on the normalized F1 and F2 were analyzed for each vowel (/a, i, o, u/) using linear mixed effects modeling with item and subject as random factors. No significant main effect of stress was found in any of the vowels, except for /o/ (F1: β = -0.25378, t = -5.451; F2: β = 0.40216, t = 5.208), which indicates that only /o/ was significantly reduced in the unstressed condition. However, as discussed in Section 5.5., it is difficult to conclude that vowel reduction occurred in this vowel, due to phonetic contexts that varied depending on the stress pattern (i.e., *páso*-type words: before *yo* 'I', *pasó*-type words: before *él* 'he'). Therefore, no further analyses were conducted on this vowel.

The results of the vowels /a, i, u/ showed that significant main effect of group and significant interaction between stress and group were found, but not consistently across vowels. Regarding /a/, HSs' /a/ had significantly lower F1 than that of the NSs (the baseline group) (β= -0.26121, t = -3.959) and a significant interaction between stress and HS was found (β = -0.22203, t = -2.524). This indicates that the difference in F1 between stressed and unstressed /a/ was larger for the NSs than for the HSs. Pairwise comparisons of stress and group confirmed that the interaction occurred due to the unstressed /a/. While HSs' stressed /a/ did not differ from that of the NSs, their unstressed /a/ had significantly lower F1 than that of the NSs ($p < 0.001$). This may have led to a larger F1 difference for the NSs than the HSs, because although it did not reach significance level, HSs' stressed /a/ a had higher F1 than the unstressed /a/ (i.e., the F1 difference between the unstressed /a/ and the stressed /a/ was negative), while NSs' stressed /a/ had a lower F1 than the unstressed /a/ (i.e., the F1 difference was positive). For the F2, a significant main effect of group was found for L2. That is, L2s' /a/ had significantly lower F2 than that of the NSs (β= -0.20013, t = -2.821). With regard to /i/, the F1 patterned similarly to that of /a/. That is, HSs' /i/ had significantly lower F1 than that of the NSs (β= -0.22423, t = -2.621) and there was a significant interaction between stress and HS (β= -0.12356, t = -2.024), which resulted from the difference in unstressed /i/ between the two groups. HSs' unstressed /i/ had significantly lower F1 than that of the NSs ($p < 0.05$). No effect of group or significant interaction between stress and group was found for the F2 of /i/. Lastly, for /u/, there was a significant main effect of group on the F1. L2s' /u/ had lower F1 than that of the NSs (β = -0.25936, t = -3.195). No effect of group or significant interaction between stress and group was found for the F2 of this vowel.

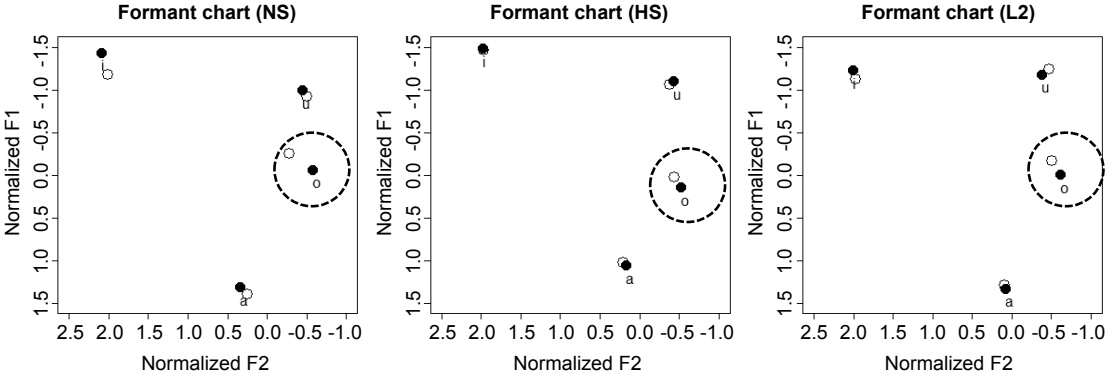

Figure 9. F1-F2 vowel plot of stressed (filled circle) and unstressed vowels (unfilled circle) of monolingual native speakers (NS), heritage speakers (HS), and L2 learners (L2) (only the vowel pair in the dotted circle had significantly different F1 and F2 values)

6.4. Discussion

The results of the production task showed group differences when comparing the durational differences between stressed and unstressed vowels both within the same word (e.g., /a/ and /o/ in *páso* and *pasó*) (see Figure 7) and across minimal pairs (e.g., stressed /a/ in *páso* vs. unstressed /a/ in *pasó*) (see Figure 8). When comparing the duration of stressed and unstressed vowels across minimal pairs, while overall the stressed vowels were produced longer than the unstressed counterparts, this difference reached significance level for all the vowels except for /i/ (i.e., /a/, /o/, and /u/) for the NSs, for only /o/ and /u/ for the HSs, and none for the L2s. Based on this finding, it seems that the HSs patterned more similarly to the NSs than to the L2s. However, when comparing the duration of stressed and unstressed vowels within the same word, the HSs showed the opposite pattern. While the NSs produced the stressed vowels longer than the unstressed vowels for both the *páso*-type words and the *pasó*-type words, the HSs and the L2s did so only for the *pasó*-type words. Regarding the *páso*-type words, in almost half of the cases the HSs and the L2s produced the stressed vowels shorter than the unstressed vowels as if they were producing *pasó*-type words. This never happened in the productions of the NSs.

Priming does not seem to have an effect on the predominant use of the *pasó*-type words (i.e., the past tense verb), since the order of stress minimal pairs and the tense of the previous word were balanced across different word types. In the case of the order of stress minimal pairs, in 18 cases the participants read the *páso*-type words before the *pasó*-type words and in 10 cases they read the *pasó*-type words before the *páso*-type of words. Regarding the tense of the previous word, in 13 cases the *páso*-type words were preceded by a present tense verb and in 15 cases they were preceded by a past tense verb. The *Pasó*-type words were preceded by a present tense verb and a past tense verb equally in 14 cases. Tonal crowding does not seem to explain the predominant use of the *pasó*-type words either, because if tonal crowding had an effect, the opposite pattern (i.e., the production of *pasó*-type words as *páso*-type words) would have been observed instead, given that the following word (i.e., subject) carried the nuclear stress.

One possible explanation for the predominance of the *pasó*-type words found in the HSs' productions is that the HSs are more accustomed to using past tense verbs. In a study using the ACTFL-OPI, a "standardized procedure for the global assessment of functional speaking ability" (www.actfl.org), Martin (2012) reported that intermediate level HSs were best in narrating in the past out of all the measures used. This suggests that it may be the case that HSs are better at processing verbs in past tense than in present tense.[11] Nevertheless this does not explain why a similar pattern was found with the L2s, because usually L2 learners learn present tense verbs prior to past tense verbs. It is likely that the L2s are more familiar with present tense verbs and thus produce this form more frequently than past tense verbs. The non-target-like behavior found in HSs' and L2s' durational differences between stressed and unstressed vowels within the same word may not necessarily be due to their production of Spanish stress *per se*; rather it may be due to the sentence structure of the stimuli. During the production experiment, there were some cases in which the HSs corrected themselves when they produced the unstressed vowels longer than the stressed vowels (e.g., *Sin duda ganó… Sin duda gáno yo.* 'Without a doubt I win'.).[12] The opposite case (e.g., *Sin duda gáno… Sin duda ganó él.*) never occurred. This indicates that the HSs did not notice that they produced the words incorrectly until the production has already taken place. Although self-correction was not found in the L2 data, it is likely that both the HSs and the L2s produced the second vowel longer than the first vowel regardless of the position of lexical stress, due to final syllable lengthening. In Spanish, like in many

[11] As a side note, in an informal conversation with a heritage speaker of Mexican Spanish, it was revealed that, given that she no longer lives with her family, the main topic discussed with her family members, with whom she speaks Spanish most frequently, is related to updates regarding her daily activities. The situation of the HSs in the present study is similar, in that all the HSs currently live away from home to attend college and, thus, when they speak to their parents on the phone or when they visit their parents, it is likely that they would talk about how they spent their days, which would be phrased in past tense, most likely in preterit, because this is the form that is generally used to express complete actions occurred in chronological order (Alonso Raya et al., 2008). However, in order to confirm that this case is generalizable to other HSs, in future research it will be necessary to add in-depth interviews regarding conversation topics that HSs have with their parents and other people with whom they speak Spanish.

[12] These tokens were not considered in the analyses.

other languages, the conclusion of an Intonational Phrase (IP) (in this case a sentence) is cued by a boundary tone, a pause, or lengthening of syllables, vowels, and words (D'Imperio et al., 2005; Prieto, 2006, Rao, 2010). Although the target words in the present study are not located in IP-final position and although none of the target words used in the analyses was followed by a salient pause, it is possible that the HSs and the L2s still treated the target word as the last word of a Phonological Phrase (PPH). A PPH is a lower tier of phrasing, in which, like an IP, the boundary is cued by lengthening of syllables, vowels, and words (D'Imperio et al., 2005; Prieto, 2006; Rao, 2010). That is, it is possible that the HSs and the L2s put a PPH boundary between the target word and the subject (e.g., [[…….gáno]$_{PPH}$ [yo]$_{PPH}$]$_{IP}$) when they should not have (e.g., [[……gáno yo]$_{PPH}$]$_{IP}$). The distribution of vowel duration also shows that there were some cases, although very few, in which the last vowel was longer than 200 ms. This is extremely long for a vowel in a non-domain final position. However, unlike an IP, the boundary is less clearly defined in a PPH (Rao, 2010). Thus, it is still questionable whether there was a PPH boundary after the target words in these cases, because no clear boundary cue was found in the present data.

If it is true that the HSs and the L2s put a PPH boundary after the target words, then this may be derived from cross-linguistic differences between Spanish and English in the realization of narrow focus and word order. That is, Spanish and English are different in that Spanish has flexible word order, while the word order in English is relatively fixed. Therefore, when there is a contrastive narrow focus on a constituent (i.e., on the subject in the case of the present study), in English it is always expressed by placing the nuclear stress on the constituent (e.g., *My BROTHER brought it.*). In Spanish, it is possible to express narrow focus by stressing the constituent *in-situ* like in English (e.g., *Mi HERMANO lo ha traído.*), but this is a marked option. Rather, narrow focus is usually expressed by shifting the constituent to the sentence-final position, which by default receives a nuclear stress (e.g., *Lo ha traído mi HERMANO.*) (Hualde, 2005). Given that both options are grammatically correct in expressing narrow focus in Spanish, it is possible that the HSs and the L2s, who are English-dominant, use the marked option (i.e., stress the focus constituent *in-situ*) more due to transfer from English. Lynch (2003) reports that "[s]ince Verb-Subject order does not usually occur in English, a lower frequency of this order is observed among Spanish H[eritage]L[earner] speakers and among L2 speakers". Therefore, it is possible that producing sentences with subject-verb inversion would be unfamiliar for the HSs and the L2s, resulting in an additional PPH boundary after the target word.

Final syllable lengthening may explain why changes in vowel quality were not found between stressed and unstressed vowels in any of the three groups that participated in the study. Given that vowel quality is not an acoustic correlate to lexical stress in Spanish, it is reasonable that the NSs did not use this cue to distinguish the stressed vowels from the unstressed counterparts. However, with regard to the HSs and the L2s, it is surprising that neither of the two groups, who are more dominant in English, reduced the unstressed vowels. This would have been expected if transfer from English had occurred, given that in English vowel quality is considered to be the most consistent cue to lexical stress. Rather, when compared with the NSs, differences were mainly found with regard to the position of the vowel categories within the vowel space (i.e., higher /a/ and /i/ for HSs and a more back /a/ and a higher /u/ for L2s). This finding is contrary to what has been found in previous studies, in which changes in heritage speakers' and L2 learners' vowel quality were observed in different stress contexts (Ronquest, 2013; Menke & Face, 2010; Willis, 2005). If final syllable lengthening occurred in HSs' and L2s' production of the *páso*-type words, this may have led both their *páso*-type words and *pasó*-type words sounding like *pasó*-type words, which may explain why vowel quality did not differ between their stressed and unstressed vowels. Further analysis is required to determine whether the HSs and the L2s produced the unstressed vowels longer than the stressed vowels in many of the *páso*-type words, because they produced most of the tokens in past tense (i.e., *pasó*-type words) or whether it is simply an artifact of positioning a PPH after the target words. Simply comparing the duration of the stressed and unstressed vowels is not sufficient to determine which tokens were produced as *páso*-type words and which tokens were produced as *pasó*-type words. Thus, it is necessary to conduct a native listener judgment task on the productions of the HSs and the L2s to separate tokens that were produced as *páso*-type words from those that were produced as *pasó*-type words and compare the vowel quality of the stressed and unstressed vowels within each stress pattern. Moreover, in order to control for the possible confounding effect of final syllable lengthening, it is necessary to examine

lexical stress in different prosodic contexts in which the target words do not appear at a phrase boundary.[13]

7. General discussion

The findings of the present study suggest that phonetic transfer is not necessarily determined by language dominance. Although English is the dominant language for both the HSs and the L2s that participated in the study, the HSs did not have difficulty perceiving stress contrasts in Spanish, while the L2s did. Given that the stress minimal pairs in the present study were differentiated mainly at the suprasegmental level (i.e., durational differences between stressed and unstressed vowels), not at the segmental level (i.e., vowel quality), attention to suprasegmental information of the stimuli was crucial in order to successfully complete the perception task. However, the L2s in the present study did not effectively use the suprasegmental information of the stimuli and instead showed bias toward the *páso*-type words, in which the suprasegmental information was less salient than for the *pasó*-type words. This finding supports previous research on L2s' difficulty in the perception of Spanish lexical stress (Saalfeld, 2009). Although the HSs have the same dominant language as the L2s (English), the HSs were able to distinguish the two stress patterns in a target-like manner. However, this does not indicate that the phonological system for their heritage language is immune to transfer from the dominant language. Unlike the NSs who produced the stressed vowels longer than the unstressed vowels regardless of the position of the lexical stress (i.e., *páso*-type words vs. *pasó*-type words), the HSs and the L2s did so only when producing the *pasó*-type words. When producing the *páso*-types words, both the HSs and the L2s produced the unstressed vowels longer than the stressed vowels in nearly half of the cases. Two possible explanations were discussed in the previous section to account for HSs' non-target-like behavior in their production of lexical stress. Firstly, the HSs may have better command in past tense verbs as was found in Martin (2012). Another probable explanation is that the HSs are not accustomed to producing sentences with subject-verb alternation and consequently positioned a PPH after the target words, which may have caused final syllable lengthening. That is, the longer duration of the unstressed vowels found in HSs' production of the *páso*-type words (and also that of the L2s) may be an artifact of the sentence structure, not necessarily due to their production of lexical stress *per se*. Further analyses should be conducted in order to tease these two possibilities apart.

The findings of the perception task and the production task imply that there may be a discrepancy between HSs' perception and production of lexical stress in Spanish. That is, while the HSs did not differ from the NSs in their overall accuracy rate when listening to Spanish lexical stress, their production was less accurate than the NSs' production. The discrepancy found in the study may result from HSs' asymmetrical use of the heritage language. As mentioned in Section 2.2., generally speaking, HSs hear the heritage language far more frequently than they speak it. While HSs are exposed to Spanish in various contexts such as in the community and through media, their production of Spanish is in general limited to familial settings, mostly with their parents. This asymmetry of use between perception and production seems to become more evident as HSs grow up, because their use of the heritage language gradually decreases as they enter institutional settings in which English is the primary or the only language used. As previous studies have shown (Major, 1992; Chang, 2010), language does not remain stable throughout life. Rather, it is malleable. Thus, even after fully acquiring a language, it is still possible to experience L1 phonetic drift from another language if the latter is used more frequently. The present study implies that HSs' production of Spanish lexical stress may be more affected by their dominant language (i.e., English) than their perception.

8. Conclusion

Previous studies on the acquisition of L2 phonology have shown that L2 learners experience phonetic transfer from L1 to L2. That is, they have foreign accent when they produce L2 speech

[13] Cross-linguistic differences between Spanish and English rhythm may also be a possible explanation to the results found in the behaviors of HSs and L2s. However, due to space constraints, the present study will only focus on differences in the realization of Spanish and English lexical stress. For more information with regard to differences between Spanish and English rhythm, refer to Carter (2005) and Wolfram et al. (2004).

sounds. This supports the idea that sequence of language acquisition has an effect on L2 phonology and it is normal that phonetic transfer occurs from the L1 to the L2, since the L1 is the language that is acquired first. However, although the importance of sequence of language acquisition is unquestionable, for L2 learners, it is usually co-varied with other factors such as language use. That is, not only that they acquired their L1 first, but also they use their L1 far more frequently than their L2. Therefore, by studying L2 learners alone, we cannot conclude that sequence of language acquisition is the most critical factor of phonetic transfer. Language dominance seems to play an important role as well. Thus, the question of what will happen when there is a mismatch between the sequence of language acquisition and language use still remains unanswered. The present study focused on this matter by examining the perception and production of Spanish lexical stress by Spanish heritage speakers, who in most cases are Spanish-English sequential bilinguals that are more dominant in English (L2). These speakers generally have better command of the heritage language than L2 learners, but not to the point that they are comparable to monolingual native speakers. Although this has been found in previous studies on heritage speakers' grammatical systems of the heritage language, there has been little research on their phonology. However, as some studies have found, heritage speakers' phonology is not exactly like that of monolingual native speakers, which supports the argument that it is extremely difficult to control both languages the same as two monolinguals (Flege, 1999; Grosjean, 2010). By examining heritage speakers' perception and production of the heritage language, the present study partially supports this view. The Spanish heritage speakers in the present study did not produce Spanish lexical stress in a target-like manner, in that they produced words with lexical stress on the penultimate syllable (i.e. *páso*-type words) as if the lexical stress was on the last syllable (i.e., *pasó*-type words), similar to English L2 learners of Spanish. Although in the present study no significant difference in vowel quality was found between heritage speakers' stressed and unstressed vowels, more research has to be done to account for the relationship between vowel duration and vowel quality. Based on the findings of the present study, which examined only three vowels (i.e., /a/, /i/, and /u/) in a sentence structure that is not present in English (i.e., subject-verb inversion), it is difficult to conclude that Spanish heritage speakers do not reduce unstressed vowels at all. For instance, Ronquest (2013) found that even after accounting for vowel duration, differences in vowel quality still remained between heritage speakers' stressed and unstressed vowels. A follow-up study with different prosodic contexts including all five Spanish vowels is underway. With regard to heritage speakers' perception, the present study found that Spanish heritage speakers were able to perceive Spanish lexical stress in a target-like manner. Given that the task was relatively simple, in that the stimuli were produced by one speaker, it would be interesting to examine whether heritage speakers are able to adjust their perception when listening to lexical stress produced by various speakers. Although at this stage it is premature to conclude that there is a discrepancy between heritage speakers' perception and production, the results found in the present study suggest that these two domains may not always match. Thus, further research is required to better understand the relationship between heritage speakers' perception and production of the heritage language. Moreover, research on heritage language phonology, including the present study, is mostly based on the assumption that heritage speakers' non-target-like behavior is due to influence from English. However, this may not necessarily be the case. For instance, Boomershine (2013) found that Spanish heritage speakers do not behave exactly the same way as monolingual native speakers of English when they perceive English vowel contrasts. Thus, in future research it is important to investigate not only Spanish heritage speakers' perception and production of lexical stress in Spanish, but also in English.

Appendix

List of target items and filler items used in the study

Target items (28 pairs)	Filler items (32)
/a/ (14 pairs)	*También lo **tiene** él.*
*Por las escaleras **bajo/bajó** yo/él.*	*En el bolsillo lo **puso** él.*
*Contento **canto/cantó** yo/él.*	*De repente **vuelve** ella.*
*Aquí lo **marco/marcó** yo/él.*	*Constantemente **comemos** nosotros.*
*Por eso **llamo/llamó** yo/él.*	*Lamentablemente **perdimos** nosotros.*
*Contento **salto/saltó** yo/él.*	*Ligeramente **corren** ellos.*
*También **pago/pagó** yo/él.*	*Tampoco lo **venden** ellas.*
*También **paro/paró** yo/él.*	*Realmente lo **quiso** él.*
*Por la plaza **paso/pasó** yo/él.*	*Finalmente lo **rompiste** tú.*
*Después lo **trago/tragó** yo/él.*	*Afortunadamente **vencimos** nosotros.*
*Aquí lo **saco/sacó** yo/él.*	*Luego lo **bebió** usted.*
*Feliz lo **salvo/salvó** yo/él.*	*En octubre **naciste** tú.*
*Igual lo **trato/trató** yo/él.*	*Lentamente **movieron** ellos.*
*Sin duda **gano/ganó** yo/él.*	*Así **dijeron** ellos.*
*Después lo **mato/mató** yo/él.*	*Siempre **salimos** nosotros.*
/i/ (7 pairs)	*En un apartamento **vive** ella.*
*Luego **miro/miró** yo/él.*	*Simultáneamente lo **cumpliste** tú.*
*También lo **cito/citó** yo/él.*	*Jamás **vino** él.*
*Después lo **tiro/tiró** yo/él.*	*Entonces **murió** ella.*
*En la pared lo **fijo/fijó** yo/él.*	*También **duermen** ellos.*
*Acá lo **firmo/firmó** yo/él.*	*Jamás lo **pedimos** nosotros.*
*Apenas **grito/gritó** yo/él.*	*En la montaña **suben** ellos.*
*Después lo **quito/quitó** yo/él.*	*Para nada **sirve** esto.*
/u/ (7 pairs)	*Tampoco **sufriste** tú.*
*Nunca **fumo/fumó** yo/él.*	*Seguramente lo **cubrió** él.*
*También lo **juro/juró** yo/él.*	*Siempre **mentimos** nosotros.*
*Igual lo **dudo/dudó** yo/él.*	*Así lo **dijiste** tú.*
*Sin evidencia **juzgo/juzgó** yo/él.*	*Aquí lo **conocí** yo.*
*También lo **busco/buscó** yo/él.*	*De repente **vino** ella.*
*Por la calle **cruzo/cruzó** yo/él.*	*En la montaña lo **perdieron** ellas.*
*Por ello **lucho/luchó** yo/él.*	*En la montaña **corrimos** nosotros.*
	*Feliz **vivieron** ellos.*

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