Stress-induced acoustic variation in L2 and L1 Spanish vowels

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Abstract

Aim: the present study assessed the effect of lexical stress on the duration and quality of Spanish vowels // produced by American English late intermediate learners of L2 Spanish, as compared to those of native L1 Argentine Spanish speakers. *Methods:* 54 real words ending in // with final and penultimate lexical stress were used as target words embedded in a short fable and a word list. Acoustic measurements of vowel duration, F1 and F2 frequencies were made. *Results:* Lexical stress affected the duration and quality (i.e. F1 only) of both L2 and L1 Spanish vowels similarly: under stress vowels had longer duration and higher F1 values while in the absence of lexical stress vowels were shorter and raised in the vowel space. Although the effects of stress were observed in the same direction across groups, English learners' stressed and unstressed vowels showed significantly longer duration and higher F1 values than native Spanish speakers' vowels. Findings also revealed compression of the L2 Spanish vowel space in the absence of stress. *Conclusion:* Findings reported in this article contribute to the overall body of literature related to the L2 Spanish vowel system and present a detailed acoustic description of Argentine River Plate Spanish, a variety not well documented in the Spanish experimental literature.

Key words: lexical stress, Spanish, English, vowel quality, duration

1. Introduction

Spanish and English share many prosodic features regarding vowels and stress. They both mark lexical stress with variations in duration, intensity and F0. They differ mostly in the size of their vowel inventories and in the absence vs. presence of phonological vowel reduction.

Research on the L2 acquisition of Spanish stress by native English learners has shown that they experienced serious difficulties in the perceptual identification of stress, that is, they evidenced “stress deafness” (Kim, 2015; Ortega-Llebaria, Gu& Fan, 2013; Romanelli, Menegotto& Smyth, 2015a, 2015b; Saalfeld, 2012). Research has also shown that stress deafness can be overcome by focused training (Romanelli, Menegotto& Smyth, 2015a, 2015b).

In this paper we study how English speakers produced the acoustic properties of Spanish vowels, assessing the effect of lexical stress on the duration and quality of Spanish vowels // as compared to native Spanish speakers. These vowels were chosen because of their importance in the identification of Spanish verbal contrasts, as the final vowel //, //, //

stressed or unstressed carries different grammatical information: *tomo, toma, tome, tomó, tomá, tomé* have different tense, mood and/or person features. ((Romanelli, Menegotto& Smyth, 2015a, 2015b)

1.1. Acoustic realization of lexical stress in English and Spanish

There are three acoustic factors related to English and Spanish stress: duration, intensity and F0. Early work on English stress which examined stress correlates in isolated words has shown that F0 is the most important cue to stress in this language (Fry, 1955, 1958), followed by duration and intensity. Further research, which explored stress cues in sentences where stressed syllables were accented (i.e. had a pitch accent), supported Fry's findings on the importance of F0 in accented contexts. However, in the absence of pitch accents, F0 was no longer a robust cue to lexical stress, rendering duration as the main cue (Beckman & Edwards, 1994; Huss, 1978; Nakatani& Aston, 1978; Sluijter& van Heuven, 1996a, 1996b). English unstressed vowels are considerably shorter than stressed ones (Delattre, 1966; Hammond, 2001).

As regards lexical stress in Spanish, previous research has also shown that F0 was the primary correlate of stress in Spanish (Enríquez, Casado& Santos, 1989; Navarro-Tomás, 1914; Llisterri, Machuca, de la Mota, Riera, and Ríos, 2003; Quilis, 1981). However, this had to do with the fact that lexical stress in these studies covaried with pitch accent, as Ortega-Llebaria&Prieto (2007) has shown. Their findings showed that in declarative sentences, F0 was a consistent cue in the identification of stressed syllables, while in unaccented sentences (i.e. parenthetic), F0 played no major role as a stress cue. Moreover, results evidenced that stressed syllables were systematically longer than unstressed syllables across intonation contexts, that is, regardless of the presence of a pitch accent. In a follow-up study, Ortega-Llebaria&Prieto (2010) found that stressed syllables were consistently longer than their unstressed counterparts across vowels (/i/ and /o/) and sentence types (declarative and reporting), confirming that duration is a strong correlate of stress in Spanish. Results also showed that Spanish speakers used overall intensity to indicate stress contrasts in reporting clauses while the spectral tilt of vowels remained unchanged across stress contexts, failing to differentiate stressed from unstressed vowels. There are also cross-language differences in stressed to unstressed duration ratios. According to Delattre (1966), English and Spanish stressed to unstressed syllable duration ratios are 1:6 and 1:3, respectively.

Taken together, these results indicate that duration is a robust cross-linguistic cue to lexical stress both in English and Spanish in accented and unaccented contexts.

The effects of stress on vowel quality in English by means of phonological vowel reduction of unstressed syllables have been traditionally attested (Lindblom, 1963). So, unlike Spanish, English uses an additional cue to identify and mark stress contrasts: vowel reduction. Campbell & Beckman (1997) compared unreduced vowels with two different levels of stress (primary vs. secondary) and found that in the absence of vowel reduction, duration and spectral tilt did not differentiate levels of stress. In a series of three experiments with nonsense synthesized vowel stimuli, Rietveld& Koopmans-van Beinum (1997) showed that the lack of vowel reduction was a cue for perceived stress when the other acoustic parameters, like F0, duration and intensity, were held constant.

On the contrary, traditional analyses on Spanish vowels have shown that stress does not affect vowel quality; that is, Spanish speakers use the same vowel categories in stressed and unstressed contexts (Hualde, 2005; Navarro-Tomás, 1914; RAE 2011; Quilis&Esgueva, 1983). Nonetheless, recent studies have reported some effect of stress on the quality of Spanish vowels, though their results are inconclusive. While some studies have found centralization of some unstressed vowels in the F1 and /or F2 dimension (Cobb &Simonet, 2015; Menke& Face, 2010; Nadeau, 2014, others have identified a raising of unstressed vowels (i.e. lower F1 values) in comparison to their stressed counterparts (Albalá, Battaner, Carranza, Gil, Llisterri&Machuca, 2008; Torreira&Ernestus, 2011). All these results provide evidence of phonetic vowel reduction, in terms of centralization or raising of some unstressed vowels in comparison to their stressed analogues, in some varieties of Spanish.

1.2. L2 speech learning models

Two influential theoretical models have been proposed to account for the processes involved in cross-linguistic speech perception and to predict the degree of difficulty in both the perception and production of non-native sounds by adult L2 learners: the Speech Learning Model (SLM) proposed by Flege (1995), and the Perceptual Assimilation Model (PAM) proposed by Best (1995) and its extension PAM-L2 (Best & Tyler, 2007). Both SLM and PAM state that at the beginning of L2 acquisition, L2 sounds are perceived through the L1, that is, previous language experience conditions L2 perception. PAM and its extension to the L2 postulate that listeners assimilate L2 sounds to the L1 sounds that perceive as more similar in terms of articulatory gestures. It predicts different degrees of difficulty in the perception of L2 contrasts by means of several perceptual assimilation patterns. For example, if two L2 sounds are mapped onto one L1 category (*single-category pattern*), and both sounds are equally good (or poor) exemplars of that L1 category, discrimination of L2 contrasts is hypothesized to be very difficult. However, if one of these two L2 sounds is considered a better example of that L1 phone (*category goodness* pattern), their discrimination should be more accurate than single-category pairs. On the other hand, if each member of a contrasting L2 pair is assimilated to two different L1 categories (*two-category* pattern), PAM predicts an excellent discrimination of the L2 contrast. Similarly, discrimination of an L2 contrasting pair is hypothesized to be very good when one L2 sound is assimilated to one L1 phone but the other one cannot be categorized, or assimilated to any L1 phone (*categorizable-uncategorizable* pattern). Finally, in such cases where two L2 phones are perceived as sounds but are not consistently mapped onto any L1 category (*uncategorizable* pattern), discrimination accuracy will vary, as it would be conditioned by the phonetic similarity of each member of the L2 pair as well as their perceptual similarity to the L1 categories.

While PAM and PAM-L2 compare L2 sound contrasts to L1 categories, SLM's predictions are based on a one-to one- comparison of sounds in the L1 and the L2. Moreover, the SLM takes into account position sensitive allophones when predicting difficulties in the acquisition of L2 categories.

1.3. L2 acquisition of Spanish stress by native English speakers

Research on the L2 acquisition of Spanish stress by native English learners has shown that they experienced serious difficulties in the perceptual identification of stress, that is, they evidenced stress deafness effects (Kim, 2015; Ortega-Llebaria, Gu& Fan, 2013; Romanelli, Menegotto& Smyth, 2015a, 2015b; Saalfeld, 2012). Nonetheless, English speakers are able to overcome their stress deafness as stress perception was shown to be sensitive to brief sessions of phonetic laboratory training and exposure to Spanish (Lord, 2003; Romanelli et al., 2015a, 2015b).

As well as showing some difficulty when perceiving stress, English speakers were also found to experience difficulties in the production of L2 Spanish stress. Romanelli et al. (2015a) found that L1 English learners of L2 Spanish differed from native Spanish speakers in the placement of stress on the final syllable in real word reading tasks and that perceptual training and exposure to the L2 had an effect on stress placement.

Not only did English speakers showed some difficulty in the placement but in the phonetic realization of stress in Spanish as well. Kim (2015) revealed that L2 learners' duration differences for *pasó*-type words were similar to those of Spanish native speakers: stressed vowels were longer than unstressed vowels. However, unlike native speakers, L2 learners produced half of the cases for *páso*-type words with longer unstressed vowels relative to their stressed counterparts. As regards vowel quality, the L2 learners did not evidence vowel reduction of Spanish unstressed vowels.

Contrary to the lack of vowel reduction reported in Kim (2015), other studies have shown acoustic variation in L2 Spanish unstressed vowels. Menke& Face (2010) reported that English-speaking learners of Spanish showed some tendency towards centralization of unstressed vowels. Cobb &Simonet (2015) reported evidence of phonetic vowel reduction of some Spanish vowels not only in L1 English-L2 Spanish speakers, but also in native Spanish speakers. On the other hand, Ruiz Mella& Soto-Barba (2005) observed, though they did not statistically confirmed, that both stressed and unstressed L2 vowels were produced with higher F1 values than native Chilean Spanish vowels, and that stressed vowels had higher F1 than unstressed ones, probably due to L1 transfer, as all five Spanish vowels have a similar English vowel which is lower in the vowel space (i.e. has higher F1 values). Changes in the F2 of L2 vowels due to stress were not clear-cut.

Phonetic vowel reduction has been shown in other studies with heritage Spanish speakers (Ronquest, 2013), late Spanish-English bilinguals (Menke& Face, 2010; RalloFabra, 2015) English learners of L2 Spanish (Cobb &Simonet, 2015), and native English speakers (Fourakis, 1991).

Finally, Colantoni, Marasco, Steele and Sunara (2014, 2015) evaluated both the phonological (i.e. placement) and phonetic (i.e. acoustic realization) aspects of the L2 acquisition of French and Spanish stress by native English speakers. Their findings showed that L2 Spanish learners were highly accurate in the placement of prominence in comparison to L2 French learners (cf. Romanelli et al. (2015a)). According to the authors, the higher accuracy of L2 Spanish learners had to do with the typological similarities between English L1 and the L2 Spanish or French prosodic systems. As for the phonetics of stress, Colantoni et al. (2014, 2015) reported that L2 Spanish learners showed higher F1 values for some unstressed vowels in comparison to native Spanish speakers, but no centralization. Regarding stressed to unstressed duration ratios, L2 speakers were shown to have greater duration ratios for some vowels but not for others in comparison to native speakers.

Taken together, these findings show that the learners' L1 influences L2 production of stress both phonologically and phonetically. However, the phonetic studies on L2 acquisition of Spanish stress described above fail to provide conclusive results about the effects of stress on the duration and quality of Spanish vowels. The reported findings are conflicting and also difficult to compare because of methodological reasons such as lack of statistical analyses or lack of dialect control of L1 and L2 groups.

The present study attempts to overcome the aforementioned limitations by carrying out an acoustic and statistical analysis of L2 vowels produced by a linguistically homogeneous group. We studied the effects of lexical stress on the duration and quality of L2 Spanish vowels produced by American English late learners of Spanish and compared learners' vowel productions to those of native Spanish speakers, in a dialectally controlled sample, providing a description of Argentinean Spanish vowels, a variety not well documented in the Spanish experimental literature.

2. Research questions and hypothesis

This paper seeks to answer the following research questions.

1. Does lexical stress affect the duration of L2 Spanish vowels?
2. Does lexical stress have an effect on the quality, measured by F1 and F2 values, of L2 Spanish vowels? Do English speakers evidence patterns of unstressed vowel reduction in Spanish?

Hypotheses:

1. Lexical stress is expected to affect vowel duration in L2 Spanish. English speakers are hypothesized to produce shorter unstressed Spanish vowels in comparison to Spanish speakers. Moreover, as the aforementioned studies have provided evidence that both English and Spanish use duration, as well as other acoustic correlates such as intensity, to cue lexical stress, it is predicted thatEnglish speakers would implement with relative ease a duration difference between stressed and unstressed Spanish vowels. English speakers are expected to produce a larger duration difference between stressed and unstressed Spanish vowels than native Spanish speakers.
2. Lexical stress will affect the quality of L2 Spanish vowels. According to PAM-L2, a perception model, it is predicted that English speakers will assimilate each L2 phone in the contrasts //-//, //-// and//-//, to a different L1 category (*two-category* assimilation), //-//, //-//, and //-//, respectively. Discrimination of two-*category* assimilation is hypothesized to be excellent. PAM-L2 predictions in the present study will be extended to the production of L2 Spanish vowels.Unlike PAM-L2, SLM proposes two hypotheses on the basis of the allophonic variation?? Position that English speakers will assimilate an L2 are expected to produce Spanish word-final stressed //, // and // with similar phonetic properties as the closest L1 categories //, / and //, respectively. They are also expected to transfer the pattern of phonological vowel reduction (i.e. neutralization of vowel contrasts in unstressed syllables) from their English L1 to the production of Spanish L2 unstressed word-

final vowels. However, as intermediate late learners of L2 Spanish with some experience with the L2, they are expected to show phonetic vowel reduction rather than phonological vowel reduction. Phonetic vowel reduction will yield less peripheral unstressed vowels in comparison to stressed vowels, that is, lower mid vowels and higher low vowels, but they will not overlap each other or be realized as schwas (i.e. grouped around the mid-center area of the vowel space). Regarding stress-induced acoustic variation, compression of the unstressed vowel space is expected in L2 Spanish.

3. Method

3.1. Speakers

The data came from 13 female native English speakers (age range = 19-26, *M*=20,6) and 10 female native Spanish speakers (age range = 19-33, *M*=28.4). The English speakers were American students from several colleges located in New York City, enrolled in a three-week study abroad program in Mar del Plata, Argentina.

A questionnaire was first administered to all the participants in the Spanish program (52 learners) to collect basic sociolinguistic information. Participants were selected based on the questionnaire and the results of placement tests. To be eligible for the experiment, participants had to be L1 English speakers and speak only English at home. Moreover, they had to have been placed in the intermediate class. L2 Spanish proficiency was determined by learners' placement test scores. Placement scores were correlated with F1, F2 and Duration on all 6 of the conditions; only one significant positive correlation was found between placement score and Duration of unstressed //, R=.643, p=.018.Because of the stringent inclusion criteria, the number of participants narrowed down to 13. On average, they have studied Spanish for 3 years, though there was considerable variation regarding the years spent studying the L2 (range= 1-7 years).

The 13 learners were comparable in terms of education, socioeconomic status as well as birthplace as determined by the questionnaire administered at the time of testing. They were all born in New York City, USA; they were all late learners of Spanish, having begun to learn it either in high school or college, and they were placed in a 201-202 language course.

Ten female speakers served as the native Spanish-speaking control group. They were all university students born in Mar del Plata, Argentina.

None of the speakers that participated in this experiment reported any speech or hearing problems in the questionnaire they filled out. It is very important to mention that we controlled for dialectal variation by pooling data of L2 learners and native speakers from New York and Mar del Plata, respectively, unlike other perception and production L2 and cross-linguistic studies (Cobb &Simonet, 2015; Escudero&Boersma, 2004; Menke, 2015; Menke& Face, 2010), as Cládková, Escudero&Boersma (2011) have shown that there are dialectal differences across Spanish vowels produced by speakers from Spain and Peru, in both F1 and F2 as well as duration. Dialectal differences have been reported in other languages (in English: Fox &Jacewicz (2009); Jacewicz, Fox & Salmons (2011)).

3.2. Speech material

Fifty-four oxytonic and paroxytonic real words ending in // were used as target words (e.g.

*tupé*and *parque*) for the present study. Target vowels were preceded by [] to reduce coarticulation effects; however, in the acoustic and statistical analyses vowels were collapsed across consonantal contexts. Target words were embedded in a text (i.e. a fable) and a word list (See Appendix A).

3.3. Procedure

Speakers were recorded individually at a quiet room at Universidad Nacional de Mar del Plata, Mar del Plata, Buenos Aires, Argentina. Each participant was seated in front of the experimenter, the first author of this paper, who was facing a computer monitor. Participants spoke to a head-mounted Pure Audio NC-1 85VM USB PC (Andrea Electronics) microphone positioned at a distance of about 1.5 inches from their lips connected to a Dell notebook. An audio software (Andrea Electronics AudioCommander) was used for recording.

Participants carried out two tasks, one after the other: the first one was a reading passage, an adapted version of the Aesop fable "The cock, the bear and the panther", while the second task was a word list (see Appendix A for tasks). Both were presented to the speakers in written form. Before the recording session, they were instructed to silently read the passage and word list to familiarize themselves with the reading material. When they were finished, they were asked to read out loud as naturally as possible the passage as well as the list.

3.4. Acoustic measurements and data analysis

Acoustic measurements consisted of vowel duration and F1 and F2 frequencies.

Measurements of vowel duration served as input to subsequent analysis of formant frequency. Vowel onsets and offsets were hand located using the synchronized waveform and spectrogram in Praat (Boersma&Weenink, 2014). Vowel onset was measured from onset of periodicity following the release burst of the stop. Vowel offset was located at the point when the amplitude dropped significantly (Fox &Jacewicz, 2009; Jacewicz, Fox & Salmons, 2011) and at the last well-formed period of the vowel (Colantoni, Steele &Escudero, 2015). In those cases where the vowel offset was followed by a word beginning with a vowel, it was located at the point in the spectrogram where the first formant of the second vowel raised.

Of the 1242 vowels segmented (54 vowels x 23 speakers (13 English; 10 Spanish)), 963 Spanish vowels were entered in the analyses (English group: 446 vowels; Spanish group: 517 vowels).

A group of three native Spanish speakers trained in phonetic transcriptions (different from the authors of this paper and the participants tested in this study) were instructed to judge vowel realizations and stress placement; inter-judge agreement was the criterion used for selecting tokens for the subsequent acoustic analysis. Interestingly, the three judges considered that 119 tokens produced by the English group were wrongly stressed, and disagreed on the identification of stress in 127 tokens. This is not surprising though, as stress perception and production studies have already shown that English speakers experience serious difficulties in the acquisition of Spanish stress (Ortega-Llebaria et al., 2013; Romanelli et al, 2015a, b; Saalfeld, 2012).

A total of 256 tokens produced by the English group and 23 produced by the Spanish group had to be discarded because of unclear formants, vowel substitutions, and mainly, due to stress misplacement.

The acoustic parameters measured, namely vowel duration, and F1 and F2 frequencies, were automatically extracted by using two Praat scripts (Lennes, 2002, 2003). Formant values were calculated at a temporal location corresponding to the 25% point in the vowel so as to eliminate the effect of consonants on vowel transitions. Unclear F1 and F2 values generated by the script were checked and re-calculated by the first experimenter.

Duration ratios as well as F1 and F2 ratios were also calculated. To assess whether the vowel space compressed in the absence of stress, F1 and F2 ratios (Audibert&Fougeron, 2012; Escudero, Boersma, SchurtRauber&Bion, 2009; Nadeu, 2014) were calculated for each of the 23 speakers individually for both stress conditions (presence vs. absence of stress). The ratio between F1 of // and the mean F1 of // and // was computed separately for both stress conditions (see Formula 1). The ratio between F1 of // and // was calculated for each speaker in the two stress conditions (see Formula 2). F1 and F2 ratios are reliable measures of vowel space size (Nadeu, 2014).

(1) F1 ratio = $F1_a/\mu(F1_e, F1_o)$

(2) F2 ratio = $F2_e/F2_o$

Repeated-measures ANOVAs with two within-subject factors, Vowel (//, //, //) and Stress (stressed, unstressed), and one between-subject factor, Group (English, Spanish) were performed on duration, and F1 and F2.

Speech rate was calculated to assess its effect on vowel duration. Speaking rate was computed by dividing the number of syllables in the passage (i.e. 315) by the total speaking time, including pauses, for each native and nonnative participant (Munro &Derwing, 1998). The passage onset was defined as the onset of frication of the voiceless fricative in the word "cierta." The offset of the passage was marked by the end of frication of the voiceless fricative in the word "oso"; the final vowel of the last word of the passage (/o/) was not considered as it was sometimes hard to segment (see Appendix A).

4. Results

A summary of results, i.e. mean F1, F2 and duration values for Spanish vowels by stress condition and group, is shown in Table 1.

Table 1 about here

4.1. Duration

The ANOVA on duration revealed significant main effects of Stress [F(1, 17)=73.963, p=.000] and Group [F(1, 17)=41.082, p=.000], but no effect of Vowel nor significant two-way or three-way interactions. The main effect of Stress indicates that both English and Spanish groups made a duration difference between stressed and unstressed vowels; regardless of vowel type, stressed vowels (English group, M=222ms; Spanish group, M=121ms) were longer than unstressed ones (English group, M=187ms; Spanish group, M=87ms). Figure 1 presents the mean duration of Spanish vowels across stress conditions for both the English and Spanish groups. The significant effect of Group reveals that there were differences between the native and non native production: Spanish vowels produced by the English group, independent of the prosodic context in which they appeared, were significantly longer than those produced by the native Spanish group (Figure 2).

** Figure 1 about here **

** Figure 2 about here**

We also calculated each speakers' stressed to unstressed duration ratios for each vowel by dividing the duration of a stressed vowel (in ms) by the duration of its unstressed counterpart (in ms) [Table 2]. The independent samples t-tests run to compare the groups' mean duration ratios revealed that there was no significant difference between the groups for /a/ ($t(14.179)=1.408$, $p=.181$) and /o/ ($t(19)=.165$, $p=.871$), but the groups' duration ratios for /e/ differed significantly ($t(19)=4.110$, $p=.001$).

** Table 2 about here **

4.2. Vowel quality

The ANOVA performed on the F1 values showed significant main effects of Vowel [$F(2,34)=371.713$, $p=.000$], Stress [$F(1,17)=40.356$, $p=.000$] and Group [$F(1,17)=8.134$, $p=.011$], as well as significant two-way interactions, Vowel x Group [$F(2,34)=4.814$, $p=.014$], Stress x Group [$F(1,17)=12.693$, $p=.002$], and Vowel x Stress [$F(2,34)=19.897$, $p=.000$]. No significant three-way interactions were found.

To investigate the Vowel x Group interaction, post hoc independent sample t-tests were carried out comparing both groups on the three vowels (collapsing Stress). The tests revealed significant differences between the English and Spanish groups in the F1 of

Spanish vowels /e/, t(19)=3.935, p=.001, and /o/, t(19)=2.491, p=.022, and a marginally significant difference in the F1 of /a/, t(19)=2.047, p=.055. English speakers' vowels were produced with significantly higher F1 values (i.e. lower in the vowel space) than Spanish speakers' vowels. Figure 3 shows F1 and F2 values for Spanish vowels produced by both English and Spanish speakers.

** Figure 3 about here**

Independent sample t-tests were also run to explore the Stress x Group interaction (collapsing Vowel). The tests showed differences between the English and the Spanish groups in the F1 of both stressed, t(17)=3.371, p=.004, and unstressed vowels, t(21)=2.443, p=.023. In comparison to the Spanish group, the English group produced both stressed and unstressed vowels with higher F1 values. The interaction between the factor Stress and Group is due to the larger F1 difference between the groups for stressed vowels (*M*=80 Hz) than for unstressed vowels (*M*=44 Hz)

Due to the significant Vowel x Stress interaction, the effects of Stress were explored on each vowel individually. The pairwise comparison between vowels in the stressed vs. the unstressed condition was significant for /a/, t(20)=5.672, p=.000, and /e/, t(20)=3.072, p=.006, but not for vowel /o/, t(20)=1.223, p=.235. These results indicate that stress affects the quality of Spanish vowels /a/ and /e/ across groups; both English and Spanish groups produced these stressed vowels with higher F1 values than their unstressed counterparts (Figure 4).

** Figure 4 about here**

As for F2, the ANOVA only revealed a significant main effect of Vowel [F(2, 34)=629.201, p=.000], while the other main effects as well as two- and three-way interactions were not significant. The significant effect of Vowel indicates differences between vowels in the F2 domain, as expected.

The fact that there was no significant effect of Stress and no interaction between Stress and Vowel and/or Group indicates that Stress did not affect the quality (i.e. backness) of any Spanish vowel and that all groups behaved alike.

To examine vowel space compression in the absence of lexical stress, F1 and F2 ratios were calculated for each of the 23 speakers individually for both stress conditions [Table 3]. A smaller F1 ratio represents a smaller distance between the mid vowels /e, o/ and the low vowel /a/, Similarly, a smaller F2 ratio indicates a shorter distance between the anterior vowel /e/ and the back vowel /o/.

** Table 3 about here **

Separate ANOVAS with F1 ratio and F2 ratio as dependent variables and Stress and Group as independent variables were calculated. The analysis of F1 ratio yielded a significant effect of Stress [F(1,17)=18.659, p=.000] but neither the main effect of Group nor the two-way interaction were significant. The effect of Stress indicates that across groups, the F1 ratio mean is shorter in unstressed vowels. In other words, both the L2 and the L1 Spanish vowel spaces are more compressed in the absence of stress than when stress is present (see Figure 4).

As for the F2 ratio, the ANOVA showed a significant interaction between Stress and

Language [F(1,17)=4.474, p=.049], but no significant main effects of Stress or Group were observed. Post hoc analyses reveal that in the absence of stress the F2 ratio mean is smaller for English speakers than for native Spanish speakers, t(21)=2.366, p=.028, while in the presence of stress groups do not differ, t(17)=.695, p=.497). Results indicate that the L2 Spanish vowel space shows a shorter distance between the anterior vowel /e/ and the posterior vowel /o/ than the native group in the unstressed condition; that is, a more compressed vowel space along the F2 dimension is observed in the L2 group in comparison to the native Spanish group (see Figure 3).

5. Discussion

We begin this study by wondering whether lexical stress affects the duration and quality of L2 Spanish vowels as compared to Argentiniannative Spanish speakers.

5.1. Duration

The results of the present study showed that English speakers differed from native Spanish speakers in the production of Spanish vowels: they produced longer vowels independently of the prosodic context. These results are consistent with those obtained by other researchers. L2 learners and bilinguals have been found to produce significantly longer vowels than native speakers (English: Guion et al. 2000; Kondo, 2000; Lee et al. 2006; German: Andreeva et al. 2015; Spanish: Ronquest, 2013; Stevens, 2011). The duration values of the L2 learners in the present study were similar to those reported in Stevens (2011), who found that study abroad American English learners of L2 Spanish produced longer vowels than native Spanish speakers before and after a four-week immersion program.

Longer L2 vowels might be the result of a slower speech rate. Munro &Derwing (1994, 1995b, 1998) have found that L2 learners often speak at a significantly slower rate than native speakers do, whether they are reading or speaking extemporaneously. Speaking rate has been found to affect L2 production in the temporal dimension (vowels: Kivistö de Souza & Mora, 2012; VOT: Schmidt &Flege, 1996; Stölten, Abrahamsson&Hyltenstam, 2015; lexical tones: Sereno, Lee &Jongman, 2015): as speaking rate increases, segment and tone duration decreases. Even though native and non-native participants in this study were instructed to read at a normal speaking rate, L2 English learners of Spanish spoke at a significantly slower speaking rate than native Spanish speakers, 2.9 vs. 5.3 syllables per second, respectively ($t(21)=9.440$, $p=.000$). A slower speaking rate and longer vowels might also be the result of having less proficiency in Spanish.

A related question was whether English speakers would produce a larger durational difference between stressed and unstressed Spanish vowels in comparison to native Spanish speakers, as English and Spanish differ on the ratio of stress-unstressduratidiffer or on 1:3 vs 1:6. Our data showed that, contrary to our prediction, English speakers did not make a larger duration difference than Spanish speakers. Why intermediate L2 learners did not shorten unstressed Spanish vowels as much as unstressed English ones is not clear. Even though English speakers were accurate in producing a similar durational difference between stressed and unstressed Spanish vowels than native speakers, they failed to produce L2 vowels in a native-like manner, as *both* stressed and unstressed vowels were significantly longer than those produced by Spanish native speakers. Longer L2 vowels, however, might be indicative of a foreign accent but might not interfere with the correct identification of stressed and unstressed Spanish vowels by native Spanish speakers. In fact, the vowels analyzed in the current study were correctly identified by three native speakers, as explained in section 3.4., so speech rate may be the key to explain most, but not all, the results found here.

It has been shown that Spanish speakers are more sensitive to smaller duration differences than English speakers (Ortega-Llebaria et al. 2013); therefore, as long as a small duration difference is produced between stressed and unstressed vowels, L2 Spanish ones are likely to be correctly identified, even when they are considerably longer than those produced by native speakers.

Native Spanish speakers in the present study consistently used duration to signal stress contrasts. Even though the magnitude of the durational difference between stressed and unstressed vowels was found to vary across studies, for example, Nadeu (2014) reported a 9% difference for Castilian vowels while we found a 28% difference, our results are in line with those reported in other research studies which showed that Spanish stressed vowels are considerably longer than unstressed vowels whether accented or not (MarínGálvez, 1995; Ortega-Llebaria, 2006; Ortega-Llebaria&Prieto, 2007, 2009).

Spanish stress has been consistently and traditionally explained by intensity more than by duration, though duration and intensity are known to interact psychoacoustically in the perception of both length and loudness. In an experiment from Kondaurova and Francis

(2008) Spanish speakers learning English relied entirely on duration to identify English tense/lax distinctions and partially to identify lexical stress. Experimental data suggests that even though length and loudness are processed as a unit, extracting length information appears to be easier than extracting loudness information and listeners' behavior is best predicted by computed measures of length. (Turk &Sawusch, 1996).

5.2. Vowel quality

The second research question inquired whether English speakers produce Spanish stressed and unstressed vowels with similar F1 and F2 values as native Spanish speakers do, and whether they reduce vowels in the absence of lexical stress as a result of L1 transfer. It was hypothesized that English speakers would experience difficulties in the production of Spanish vowels in both stress conditions, as each L2 sound has a phonetically similar L1 sound to be assimilated to. Our results partially confirm the aforementioned hypothesis, as English speakers' stressed and unstressed vowels significantly differed from native Spanish ones in height (F1) but not in backness (F2). L2 Spanish vowels /e/ and /o/, and to a lesser extent /a/, were produced with significantly higher F1 values than native Spanish vowels. Other L2 studies have reported higher F1 values for Spanish vowels produced by L2 English learners in comparison to Spanish speakers (Menke, 2015; Ruiz Mella& Soto-Barba, 2005).

Higher F1 values for L2 Spanish vowels could be explained in reference to the American English vowel system. As suggested by Rochet (1995), L2 vowel categories may be identified as realizations of L1 vowels. For every Spanish vowel, there is a similar but more open corresponding vowel in English. By studying the F1 values of American English vowels reported in Hillenbrand et al. (1995), we can observe that L2 Spanish /e/ (F1: 609 Hz, averaged across stress conditions) falls between English // (F1: 536 Hz) and English / / (F1: 731).

It could be possible that English speakers had been taught that Spanish mid vowels are not diphthongized, and hence, avoided diphthongization, as for native Spanish speakers it would be an indicator of foreign accent (Hammond, 2001; Whitley, 2002). Thus, rather than using the English diphthongized category, they might have produced a more open Spanish /e/, similar to the English category, //. Similarly, L2 Spanish /o/ (F1: 645 Hz, averaged across stress conditions) falls within the range of English // (F1: 555) and // (F1: 781). As again, // might not have been an option because it is diphthongized, English speakers might have produced a more open L2 category, similar to their L1 //. Even though the difference between L2 Spanish /a/ and native Spanish /a/ reached a marginal significance, it can be noted that English speakers also produced Spanish /a/ with a higher F1 than native Spanish speakers. As for the other vowels, L2 Spanish /a/ might have been assimilated to the more open English vowel //, and therefore produced with higher F1 than the native Spanish /a/.

Interesting to note is that our results have shown that stress affected not only L2 but also L1 Spanish vowels (Vowel x Stress interaction). The effect was found in the same direction across groups: stressed /a/ and /e/ were lower in the vowel space (i.e. higher F1) than their unstressed counterparts. Thus, vowels were shifted up in the vowel space when unstressed. Note that the non significant difference in F1 between stressed and unstressed /o/ across groups could be due to speaker variation, as some speakers showed the effect in one direction, and others, in the opposite one. While seven L2 speakers produced higher unstressed vowels, in accordance with the strategy that most have been using for the other unstressed vowels, the rest produced lower vowels. Similarly, but in the opposite direction, while seven native speakers lowered their unstressed /o/ relative to their stressed vowel, the remaining three raised their /o/. In other words, there was a robust effect of stress across groups on the F1 of vowels /a/ and /e/ only. The shifting-up in the F1 for unstressed vowels /a/ and /e/, however, took place without a significant change in F2 for any of the groups.

Although we predicted phonetic vowel reduction for all three unstressed L2 Spanish vowels, yielding lower mid vowels and higher low vowels, the acoustic data presented here evidenced reduction at the phonetic level in the predicted direction only for unstressed //. This pattern was observed not only in the L2 learner group but also in the L1 Spanish group. Raising unstressed vowels in comparison to stressed ones was found in other L2 and L1 studies. Cobb &Simonet (2015) observed that intermediate English learners of L2 Spanish produced unstressed // and // with lower F1 values (i.e. higher in the vowel space) than stressed // and //. Menke& Face (2010), however, reported that all three groups of English learners of Spanish showed centralization of unstressed vowels on the front-back dimension. As for native Spanish speakers, Nadeu (2014) and Cobb &Simonet (2015) observed an upward shift for unstressed // only, while Albalá et al. (2008) reported a significant upward shift in the F1 for unstressed // and //, but not for unstressed //. On the other hand, Ronquest (2013) showed that heritage Spanish speakers raised all three unstressed vowels. This acoustic variation observed for Spanish vowels in the absence of stress conflicts with the more traditional view that Spanish vowels maintain the same quality regardless of the prosodic context in which they appear (Hualde, 2005; Navarro Tomás, 1914; Ortega-Llebaria&Prieto, 2011; Quilis, 1981; Quilis&Esgueva, 1983).

Lowering of F1 for unstressed vowels in comparison to stressed vowels has also been observed in another five-vowel stress language unrelated to Spanish: Tongan, a Malayo-Polynesian, Austronesian language (Blust, 2009). Garelleck& White (2015) reported that all five Tongan unstressed vowels were shifted upwards in the vowel space relative to vowels with stress. This pattern, present both in Tongan, and L1 and L2 Spanish, could be interpreted in reference to the sonority expansion hypothesis (Beckman et al. 1992), by which prominent (i.e. stressed/accented) vowels, irrespective of vowel height, show enhanced sonority. That is, prominent vowels are produced with a more open vocal tract (i.e. higher F1 values in acoustic terms) increasing sonority.

Articulatory and acoustic studies have found evidence of enhancement of phonological vowel features such as sonority in English (Cho, 2002, 2005; de Jong, 1995). Cho (2002, 2005) found an increase in jaw and lip openings for English high and low vowels // when accented, indicating sonority expansion. Similarly, acoustic data supported the enhancement of the sonority feature for accented // (Cho, 2002, 2005) and // (Harrington et al. 2000), as shown by an increase in F1. Further support for sonority expansion in English has been shown by the positive correlation between perceived prominence and F1. Mo et al. (2009) demonstrated that higher F1 values correlated with higher prominence scores (i.e. a perceptual measure of prominence) independently of vowel height, thus attesting that vowels perceived as prominent by native American English listeners tended to show increased sonority. Given these findings, we could infer that English speakers approached the acquisition of Spanish with an enhanced sensitivity to higher F1 values to indicate vowel prominence. Speakers might have favored sonority expansion over the enhancement of other phonological features for the sake of listeners' better identification of stressed segments in Spanish.

The analyses of F1 and F2 ratios showed that the absence of lexical stress caused shrinkage of the vowel space of L2 English learners of Spanish, as expected. Results revealed that both the L2 and the L1 Spanish vowel spaces were more compressed in the vertical dimension in the unstressed condition (i.e. smaller F1 ratios) relative to the stressed condition, while in the absence of stress a more compressed vowel space along the F2 dimension was observed in the L2 group (i.e. smaller F2 ratio) than in the native Spanish group. A shrunken vowel space in the unstressed condition was expected in the English group due to the fact that English is a language with phonological vowel reduction. Native English speakers have shown smaller distances between L1 vowels in the unstressed condition in comparison to late L1-Spanish L2-English bilinguals, as measured in terms of Euclidean distances (RalloFabra, 2015).

5.3. Limitations of the present study

Pitch accent and prosodic phrasing were not controlled for in the experiment. The reading task, particularly the fable used for eliciting vowel production, rendered the use of different pitch accents and accentual phrases. Even though Ortega- Llebaria&Prieto (2007) have found that the presence of a pitch accent does not consistently amplify neither vowel quality nor duration in Spanish, it has been shown that pitch accent as well as prosodic phrasing affect segments in other languages (Cho, Lee & Kim, 2011; Cho & McQueen, 2005). Therefore, future studies should control for these factors.

6. Conclusion

The primary goal of the present paper was to examine the effect of lexical stress on Spanish vowels produced by a group of English late L2 learners of Spanish, and a control group of native Spanish speakers. The results evidenced stress-induced acoustic variations in L2 and L1 Spanish vowels: lexical stress was found to affect both the duration and quality (F1 only) of Spanish vowels alike. L2 and L1 unstressed vowels underwent temporal reduction in comparison to stressed vowels. Moreover, while absence of lexical stress in L2 and L1 Spanish entailed phonetic reduction by raising // and //, presence of lexical stress resulted in increased sonority as indicated by higher F1 values. However, in comparison to native speakers, English learners of Spanish produced both stressed and unstressed vowels with longer duration and higher F1. The results also showed that the absence of lexical stress triggered compression of the vowel space along the F1 and/or F2 dimension.

These findings contribute to the overall body of literature related to the L2 Spanish vowel system and present a detailed acoustic description of Argentine River Plate Spanish vowels in the 21st century.

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Appendix A, Speech material

<u>A. Leé la fábula "*El oso, el gallo y la pantera*"</u>

Cierta vez, un oso torpe y fofo y un gallo de campo se unieron para recorrer Europa. Una noche, el gallo trepó a un árbol y el oso se acostó al pie del tronco. Y como era su costumbre, el gallo cantó fuerte antes del amanecer. Una astuta pantera oyó su canto y corrió hacia el lugar, se paró al pie del árbol y le imploró que bajara, porque quería ver de cerca al dueño de tan hermosa voz. El gallo de campo le replicó: "*hacé así: despertá primero al portero de kipá y tupé que está durmiendo al pie del tronco*". La pantera vio al pie del tronco al oso dormido, se acercó y comenzó a hablarle. El oso torpe y fofo se despertó sobresaltado, vio a la pantera, y de pronto, le saltó encima y la devoró de prisa. La moraleja de la historia, en las palabras del gallo: *"Sé inteligente, buscá a alguien más fuerte que vos si tu enemigo es muy poderoso. Buscá a alguien que esté cerca, como yo que busqué a mi amigo el oso.*

<u>B. Leé las palabras:</u>

1. mire	21. yanqui
2. astuta	22. replicó
3. triunfo	23. catástrofe
4. pensé	24. miró
5. Europa	25. fuerte
6. tupé	26. encontré
7. papi	27. campo
8. jefe	28. fe
9. tronco	29. compu

10. pero 11. kipá 12. espíritu 13. parque 14. pensó 15. saltó 16. alegre 17. cerca 18. clase 19. torpe 20. despertá	30. buscá 31. canto 32. anti 33. estafó 34. esté 35. trepó 36. caqui 37. café 38. busqué 39. caso

Table 1.

	English group						*Spanish group*					
	Stressed			Unstressed			Stressed			Unstressed		
	F1	**F2**	**Dur**	**F1**	**F2**	**Dur**	**F1**	**F2**	**Dur**	**F1**	**F2**	**Dur**
a	852 (67)	1632 (89)	198 (102)	758 (65)	1678 (54)	185 (37)	781 (56)	1670 (112)	126 (16)	744 (42)	1686 (59)	96 (15)
e	632 (82)	2156 (154)	239 (60)	590 (55)	2173 (109)	195 (52)	520 (46)	2255 (93)	127 (24)	508 (35)	2217 (68)	76 (9)
o	654 (56)	1241 (166)	214 (63)	631 (48)	1283 (143)	182 (47)	591 (43)	1216 (40)	110 (15)	595 (46)	1165 (57)	89 (16)

Table 2.

	English group	*Spanishgroup*
a	1.1 (.52)	1.3 (14)
e	1.3 (.24)	1.7 (.16)
o	1.3 (.51)	1.3 (.22)

Table 3.

	English group		*Spanishgroup*	
	Stressed	Unstressed	Stressed	Unstressed
F1 ratio	1.4 (.14)	1.3 (.11)	1.4 (.05)	1.3 (.05)
F2 ratio	1.8 (.23)	1.7 (.23)	1.9 (.10)	1.9 (.11)

Tableheadings

Table 1. Mean F1, F2 and duration (i.e. Dur) values for Spanish stressed and unstressed vowels produced by the English and Spanish groups. Standard deviations are presented in parenthesis.

Table 2.Stressed to unstressed duration ratios for /a, e, o/ by group. Standard deviations are in parenthesis.

Table 3.F1 and F2 ratios for the English and the Spanish groups in both stress conditions. Standard deviations are in parenthesis.

Figure legends

Figure 1. Mean duration of Spanish vowels produced by the English and Spanish groups across stress conditions.

Figure 2. Mean duration of Spanish stressed and unstressed vowels by group.

Figure 3. Mean F1 and F2 values for Spanish vowels by group. Ellipses represent one standard deviation.

Figure 4. Mean F1 and F2 values for both English and Spanish groups by vowel type and stress conditions. Ellipsesrepresentonestandarddeviation.