HISPANIC STUDIES
review

Mexican heritage Spanish speakers' vowel production in cognate and non-cognate words

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Abstract

Previous research describes the Spanish vowel system as a stable five-vowel system (Delattre, 1969; Hualde, 2005; Navarro Tomás, 1918). Recent findings have challenged this claim (Delforge, 2008; Willis, 2005) with reduction of unstressed vowels reported in monolingual Mexican Spanish (Butragueño, 2014). Variation of the vowel system has also been reported in studies of heritage Spanish (Boomershine, 2012; Ronquest, 2012). The current study examines Mexican heritage Spanish (i.e. early bilingual) vowel production in cognate and non-cognate words in comparison to a late bilingual group. Both early bilinguals and late bilinguals show a constricted back vowel space and a wider front vowel space in cognate and non-cognate words. Vowels in cognate words showed significantly more centralization than those in non-cognate words.

1. Introduction

Previous research has stated that the Spanish vowel system is a stable five-vowel system with little variation (Delattre, 1969; Hualde, 2005; Navarro Tomás, 1918). Recently, however, this claim has been questioned as researchers have found much more variation in the Spanish vowel system than previously thought (Delforge, 2008; O'Rourke, 2010; Marín Gálvez, 1995; Menke & Face, 2010; Willis, 2005). One such example is the reduction of unstressed vowels reported in monolingual Mexican Spanish (Boyd-Bownman, 1952; Canellada & Zamora, 1960; Lope Blanch, 1963/1964; Matluck, 1952; Butragueño, 2014). Other studies on Spanish vowel production in monolingual and bilingual Spanish noted varying degrees of unstressed vowel reduction in terms of quality and duration (Delforge, 2008; Marín Gálvez, 1995; Gordon, 1980; Lipski, 1990; Menke & Face, 2010; Willis, 2005). Variation of the vowel system has also been reported in studies of heritage Spanish (Boomershine, 2012; Ronquest, 2012). Research on heritage language Spanish has indicated that cognate status may be a significant factor in the realization of the voice onset time of /t/ in English cognates (Amengual, 2012) but it is still unknown if cognate status plays a role in heritage Spanish vowel production.

In previous studies, the heritage Spanish speaker vowel space appeared to be more asymmetrical and less triangular than that of monolingual native speakers of Spanish (Boomershine, 2012; Ronquest, 2012). These studies note that unstressed vowels tend to reduce or centralize to a greater degree than in monolingual varieties of Spanish (Alvord & Rogers, 2014; Boomershine, 2012; Ronquest 2012, 2013; Willis, 2005). Rao and Ronquest (2015) argue that despite recent work, research regarding the heritage vowel system remains limited. The current study attempts to add to the research on heritage Spanish speaker vowel productions by examining the vowel quality in productions of cognate and non-cognate words. Investigating vowel production in

cognate versus non-cognate words may provide insight into possible cross-language phonetic influences in Spanish-English bilinguals' vowel production.

This article is divided into several sections. The first section provides a brief overview of the Spanish and English vowel system as well as previous research regarding heritage Spanish (i.e. both sequential and simultaneous early bilinguals) vowel productions. The subsequent section describes the current study, the participants, materials, procedures, and data analysis followed by the results and discussion. The limitations and conclusions are considered in the last two sections of the article.[1]

2. Previous Research

2.1 Spanish Vowel System

Seminal studies have highlighted the stable nature of the Spanish vowel system while fewer studies have examined the acoustic properties of vowels as compared to Spanish consonants (Delattre, 1969; Hualde, 2005; Navarro Tomás, 1918). In one of the first studies to examine the Spanish vowel system, Quilis and Esgueva (1983) showed slight differences in vowel quality and duration based on stress and speaker sex. Furthermore, the effect of lexical stress on vowel quality and duration was minimal. However, more recent acoustic descriptions of Spanish vowels in less controlled speech styles demonstrate that there is much more dialectical and stylistic variation than had previously been claimed (Delforge, 2008; Alvord & Rogers, 2014; O'Rourke, 2010; Marín Gálvez, 1995; Menke & Face, 2010; Willis, 2005). Distinct distributions of vowels in Quechua-Spanish and English-Spanish bilinguals were reported in O'Rourke (2010) and Menke and Face (2010). Alvord and Rogers (2014) and Menke and Face (2010) found unstressed vowel centralization in populations of Miami-Cuban bilinguals and bilingual speakers in the Southwestern United States. Willis (2005) noted a more fronted /u/, a lower /o/ and a fronted /a/ in the production of Spanish-English bilinguals in the Southwestern United States.

2.2 Mexican Spanish vowels: From impressionistic to acoustic studies

A detailed description of Mexican Spanish vowel production is necessary as the speakers in the current study are Mexican American and Mexican speakers of Spanish. With regards to Mexican Spanish, impressionistic and acoustic studies report reduction of unstressed vowels (Boyd-Bownman, 1952; Lope Blanch, 1963/1964; Matluck, 1952). In an impressionistic study, Boyd-Bowman (1952) argued that reduction of atonic vowels occurred when in contact with /s/ and other voiceless consonants. Reduction was most prominent when followed by word-final /s/, although all of the vowels except /a/ were reduced. Matluck (1952) noted similar findings in his impressionistic study of Spanish spoken in Valle de México. He argued that vowels followed by a voiceless consonant such as /s/ were more likely to reduce than those followed by a voiced consonant. His findings showed that Mexican pronunciation of /a/ was different than that of standard Spanish, as it did not exhibit as much velarization in stressed position before /x/ and /l/. In closed syllables, the stressed /e/ was more open and produced as an [ɛ]. Lope Blanch (1963/1964) argues that reduction is a gradient phenomenon based on his impressionistic analy-

1 I would like to thank reviewers for their insightful comments and suggestions that led to an improved version of the work. I would especially like to thank Dr. Tim Face and Dr. Mandy Menke for providing their feedback on earlier drafts.

sis of unstressed vowel production in spontaneous conversation. He reported that the position of the vowel in the word was not as significant a factor in weakening of unstressed vowels as had been previously noted in Boyd-Bowman (1952) and Matluck (1952). However, in accordance with the findings of Boyd-Bowman (1952) and Matluck (1952), he found that reduction of the vowels occurred frequently when the vowel was in contact with /s/. Moreover, the vowel /e/ was reduced more than other vowels in Mexican Spanish. These impressionistic studies provided some of the first accounts of the unstressed vowel reduction in Mexican Spanish. Lipski (2004; 2008) echoes these findings by stating that central Mexican Spanish shows a tendency to reduce unstressed /e/ when in contact with /s/. He suggests that /i/ is subject to this reduction in Mexican American Spanish and that the vowel /e/ in Mexican American varieties is produced lower and farther back in the vowel space.

Poch Olivé, Harmegnies, and Butragueño (2008) examined the effect of speech style (i.e. spontaneous or laboratory style) on centralization and vowel clustering (i.e. the degree to which the formant distributions in the acoustic space cluster together) in Mexican Spanish. Results show that while /i,e,o,u/ showed significant centralization in spontaneous speech, /a/ remained relatively stable in both tasks. Speakers produced the high vowels with more open articulation, that is, lower in the vowel space. The two back vowels showed greater overlap than the other vowels, while vowels /i/, /e/, and /o/ showed greater clustering overall in the acoustic space. The heritage speakers that participated in this study are Mexican American speakers of Spanish; thus, the analyses will help determine if unstressed vowel reduction occurs in cognate words.

2.3 The English vowel system

In this section, I will provide a brief discussion of the U.S. English vowel system, as the speakers in this study utilize and are exposed to U.S. English as opposed to British English. In contrast to the five-vowel system of Spanish, accounts of U.S. English show that the number of phonemes vary from 9 to 14 vowel productions (e.g. Bradlow, 1995; Delattre, 1965). Spanish has pure mid vowels while English has dipthongizing vowels, resulting in the pronunciation of Spanish sounds /e/ and /o/ and the English sounds /ei/ /eɪ/ and /oʊ/. Spanish mid vowels are higher and tenser than their English counterparts while the Spanish /a/ is more fronted than in English. Spanish /o/ and /u/ are produced with more lip rounding than their English counterparts.

In comparative analyses, Delattre (1965) noted that English vowels occupy more space overall than Spanish vowels. However, Bradlow (1995) argues that the acoustic vowel spaces of the two languages are not significantly different but that all of the English vowels show more fronted productions than the Spanish vowels. While Delattre (1965) noted higher realizations for /i/ and /e/ in Spanish, Bradlow (1995) argues that /i/ and /e/ are produced higher in English. Stress plays a prominent role in the realization of English vowels. Delattre (1965) notes that reduction of unstressed vowels is common in English (17.78%) whereas in Spanish, reduction was infrequent (3.65%). In English vowel productions, this reduction takes the form of centralization. Delattre (1965) also reported that 22.99% of the vocalic productions were [ə]. In summary, English and Spanish have a different number of vowel phonemes with varying formant frequencies and positions in the vowel space, dipthongization, and reduction.

2.4 Heritage Spanish vowel production

Studies regarding vowel production of heritage Spanish speakers have reported that the

heritage speaker vowel space may not be as symmetrical or triangular as that of monolingual native speakers of Spanish (Willis, 2005; Boomershine, 2012; Ronquest, 2012). Willis (2005) found a fronting of /u/ and a lowering of /o/ in heritage speaker Spanish along with a fronting of /a/ in the direction of English /æ/. Boomershine (2012) and Ronquest (2012) found similar results in heritage Spanish of North Carolina and Chicago, respectively. Both authors also reported a condensed back vowel space and wider front vowel space. Ronquest (2012) noted that /e/ was produced farther back in the vowel space while /u/ appeared in a more fronted position.

Lexical stress and speech style have also proven to affect heritage Spanish speaker vowel production. Previous investigations document a greater tendency for unstressed vowels to reduce or centralize in comparison to monolingual varieties of Spanish (Alvord & Rogers, 2014; Boomershine, 2012; Ronquest 2012, 2013; Willis, 2005). For example, Ronquest (2013) noted that unstressed /e/, /a/, and /o/ were produced with lower F1 frequency measurements (i.e., higher) than stressed /e/, /a/, and /o/ while unstressed /i/, /e/, /o/, and /u/ shifted towards the center of the vowel space along the F2 dimension. With respect to vowel duration, Ronquest (2013) notes that atonic vowels were significantly shorter than tonic vowels. She also found that vowels were more centralized, but that this centralization was not the result of shorter duration of atonic vowels. While one might suspect that centralization and reduction of unstressed vowels in the heritage speaker vowel system is a result of English contact, Ronquest (2013) contradicts this idea based on the evidence that centralization is not always in the direction of the schwa, which is what English influence would predict.

Previous studies have not examined the effect of cognate words on the vowel production of heritage speakers of Spanish despite previous research which shows cognate effect to be a significant factor in the production of heritage speakers' voice onset time (VOT) of /t/ in English cognates (Amengual, 2012). Amengual (2012) states that this is in line with earlier studies which show stronger cross-language phonetic influences in Spanish-English bilinguals' production of cognate words, and that the results provide further evidence that "language systems of bilinguals do not operate completely independently of one another" (p. 526).

These studies provide evidence that the heritage Spanish vowel system differs from the symmetrical Spanish vowel system by comparing the heritage Spanish vowel system with traditional accounts of the Spanish vowel system, and that cognate words may enhance cross-linguistic phonetic influences. None of these studies, apart from Amengual (2012), incorporated their own comparison groups, instead relying on accounts of monolingual Spanish. In the current study, heritage speaker groups are compared to other bilinguals who began learning English as adults. Since heritage speakers are in fact, bilinguals, it is more appropriate to compare them with other bilinguals with differing language learning experiences. This is in line with the recommendation of Cook (1992) and Ortega (2013, 2014, 2015) who suggest that bilinguals should serve as the "target" when analyzing bilingual language, as the competence of bilinguals is fundamentally different from that of monolinguals. In an attempt to add to the growing body of literature regarding the heritage Spanish vowel system, this study examines the vowel production of two heritage speaker groups and late bilinguals (i.e. those who began learning English as an adult). The two heritage groups consisted of speakers who were born in Mexico and moved from a monolingual to bilingual environment (i.e. sequential bilinguals) and speakers who were born in the United States in a predominantly bilingual environment (i.e. simultaneous bilinguals). In previous studies, Guion (2003) noted differences between simultaneous and sequential bilinguals' vowel production. As such, separating the heritage groups accounts for any possible differences language learning experience may have on vowel production. In addition, this study

considers the role of cognate status on the production of Spanish vowels.

3. Experiment

3.1 Participants

In order to examine the vowel quality of the heritage Spanish vowel system in cognate versus non-cognate words the following research questions were posited:

1. How do the Spanish vowels of heritage speakers compare to those of late Spanish-English bilinguals in terms of vowel quality (i.e., F1 and F2 values)?
2. Do the vowel productions in cognate words differ from those in non-cognate words across the three groups? If so, how?
3. What is the effect of lexical stress on vowel quality in cognate and non-cognate words? How does this compare across groups?

For the purpose of examining the vowel quality of cognate versus non-cognate words, nine heritage speakers of Mexican Spanish living in the United States were recruited (3 males, 6 females) to participate in the present study. The sample consists of university students with a mean age of 19.12 years (range 18-22) (See Table 1). Participants were recruited based on their self-identification as a heritage speaker. In other words, all speakers identified as early sequential and simultaneous bilinguals who were raised and educated almost exclusively in the United States. The participants all have exposure to both English and Spanish on a daily basis. Participants noted that while they use Spanish in the home with their families, they use primarily English in social interactions at school or outside of their home. All participants completed their education in the U.S. with the exception of speaker H8 who completed first through fourth grade in Mexico. This information was gathered from a questionnaire that asked them to describe their experience with Spanish and English growing up (see Appendix C for language background questionnaire)[2]. The nine heritage speakers were divided into two groups; the first group included speakers who were born in Mexico and were Spanish dominant upon entering the educational system of the United States (see Table 1). The second group consisted of speakers who described themselves as equally dominant in Spanish and English upon entering school in the United States (see Table 2). As the definition of "heritage speaker" presents a wide-range of variability in the literature and is considered a "heterogeneous group" with varying degrees of Spanish proficiency (see Potowski, Jegerski, & Morgan-Short, 2009; Montrul, Foote & Perpiñan, 2008) it may be necessary to take into account language learning experiences and the social reality of the speakers when forming subject groups for comparison in empirical research. The comparison group, listed in Table 3, consisted of two males and one female from Mexico who had moved to the United States at or after the age of 18. These speakers started learning English at or after the age of 14 and reported using both Spanish and English on a daily basis at home and in the workplace and are classified as "late bilinguals."

2 The questionnaire was adapted from the Bilingual background questionnaire for Spanish/English speakers created by Silvina Montrul (2012). The questionnaire was designed to gather information about the language use, language attitudes and self-perceived language proficiency of Spanish-English bilinguals in the United States.

Table 1. Participants: Group 1, Born in Mexico

Participant	Sex	Age	Age of Arrival to the U.S.
H1	Female	18	Age 5
H5	Male	20	Age 4
H7	Female	19	Age 6
H8	Male	22	Age 10
H9	Female	22	Age 4

Table 2. Participants: Group 1, Born in the US

Participant	Sex	Age	Age of Arrival to the U.S.
H2	Female	18	Born in the US
H3	Female	18	Born in the US
H4	Male	18	Born in the US
H6	Female	21	Born in the US

Table. 3. Comparison Group: Late Bilinguals

Participant	Sex	Age	Age of Arrival to the U.S.
LB	Female	28	After 18
LB	Male	31	After 18
LB	Male	45	After 18

3.2 Materials

The materials consisted of a total of 78 Spanish sentences (see Appendix B for sentences) that were presented one by one on a Powerpoint slide. Each sentence contained one or several target words within a sentence such as "El corredor ganó una medalla de oro (The runner won a gold medal)" or "Ella lleva perfume todos los días (She wears perfume every day)." All of the sentences were checked by another linguist and a native Spanish speaker in order to ensure grammaticality and correct sentence structure. All vowel tokens occurred between consonants; however, context was not controlled due to the level of difficulty of identifying cognate words that maintain similar contexts. There were 10 cognate words (i.e. cognate pairs with similar meanings and phonological structure in both languages) and 10 non-cognate words (i.e. words lacking any orthographic or phonological overlap with their English translation equivalents) presented for each of the five Spanish vowels. All attempts were made to have an even number of stressed and unstressed vowels in word-internal position. The number of stressed and unstressed vowels in cognate and non-cognate words is listed in Table 4 below.

Table 4. Number of stressed and unstressed vowels

Vowel	Cognate		Non-Cognate	
	Stressed	Unstressed	Stressed	Unstressed
/a/	7	3	7	3
/e/	4	6	6	4
/i/	4	6	8	2
/o/	4	6	6	4
/u/	3	7	5	5

Cognate words were chosen for their phonological "mis-match" from Spanish to English. For example, the vowel quality of /e/ in Spanish "obediencia" is different than in English "obedience" where the vowel is /i/. This contrast will facilitate the analysis of possible English effect on vowels in the Spanish word. Overall there were 100 tokens (50 cognates and 50 non-cognates) for each participant.

3.3 Procedure

Participants were asked to complete two tasks. The first task consisted of the background questionnaire that was mentioned in section 3.1. The questionnaire was used to gather biographical data on each of the participants and their experiences speaking English and Spanish throughout their lifetime. The second task was an oral reading of the Spanish sentences (see Appendix B). A more formal task was required to ensure that participants produced the target cognate. It is important to note, however, that task formality can have an effect on production. For example, Zampini (1994) found that Spanish spirantization was more accurate in informal than formal tasks. In their study examining heritage speakers' and long-term immigrants' intonation of broad focus declaratives, Colantoni, Cuza, and Mazzaro (2016) contend that the significant difference between groups is a result of task formality. They suggest that language learning/literacy conditions for each group can cause distinct productions in more formal reading tasks and more informal oral narratives. As a result, they argue that less-controlled tasks are more illustrative of the speech of both groups, as the use of reading tasks shows a clear advantage for speakers who are educated in the language being tested (p. 20). Nevertheless, a reading task was used in the current study as the goal was to elicit specific cognate word pairs. The sentences were presented individually through PowerPoint. The participants conducted the experiment using a tablet which required them to tap the screen to move on to the next slide. Participants were asked to read the sentences aloud at a normal pace while being recorded with a Marantz digital recorder.

3.4 Data Analysis

Each token was extracted from the speech stream before the F1 and F2 were measured. The F1 and F2 values were measured at the center point of the vowel by an LPC formant-tracking algorithm (script) in Praat (Boersma & Weenik, 2014). After the initial measurements were taken, random-hand checking was done to ensure accurate measurement of the vowel. All outliers were checked a second time to ensure accurate measurement. A total of 1,158 vowel tokens were analyzed as part of this study. Thirty tokens were excluded due to unexpected background noise and/or creaky voice. The formants were normalized using the Lobanov method in the web-based NORM suite interface (Thomas & Kendall, 2012). The Lobanov method calculates a normalized formant measurement for each vowel based on the mean and standard deviation for that formant throughout the speaker's vowel system.

Statistical analyses were conducted to determine the relationship between vowel quality, speaker group, cognate status, and lexical stress. Using R statistical software and lme4 package (Bates, Maechler, Bolker, & Walker, 2015), separate mixed effects models were created (one for the F1 and F2) for each of the five vowels. It should be noted that for each vowel there is a different number of effects for each vowel as some of the variables were collapsed or eliminated

due to overlap. The independent variables included cognate status, age of arrival to the United States, and lexical stress. Speaker was included as a random effect while Age of Arrival (i.e. born in the United States, born in Mexico, arrived in the United States after 18 years of age), Cognate Status, Lexical Stress and the interaction of these factors were included as fixed effects. The significance level was set at .05.[3]

4. Results

1,128 heritage speaker vowels were compared to 300 vowels produced by the control group (i.e. late bilinguals). Participants born in Mexico produced 626 tokens while 502 came from those born in the United States.

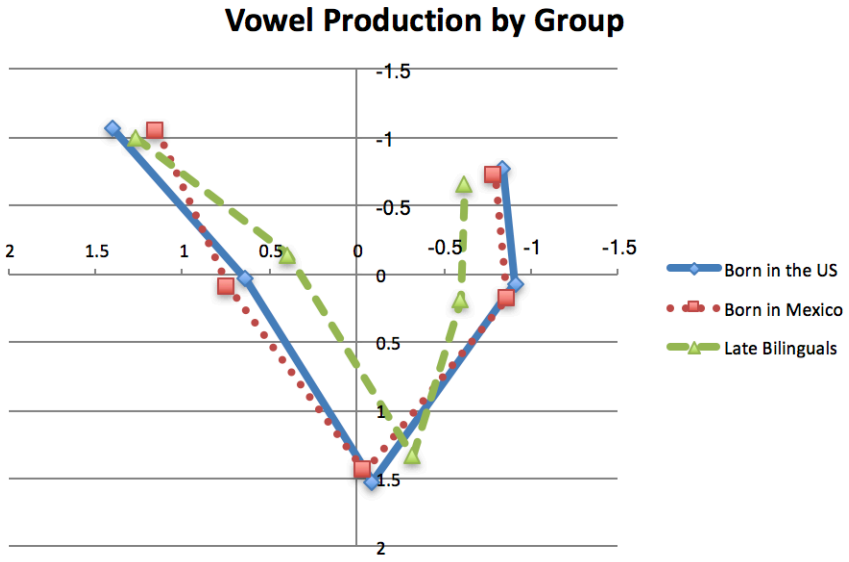

Figure 1. Vowel plot showing average normalized F1 and F2 values by group

As shown in Figure 1, vowel production across groups shows slight differences in the productions of late bilinguals and the two heritage speaker groups. Late bilinguals produce more fronted back vowels. The low vowel /a/ for late bilinguals shows slightly lower F2 values. Overall, the vowel space of all groups is asymmetrical with condensed back vowels /o/ and /u/ and open front vowels /i/ and /e/. Results of the linear mixed effects models showed a statistically significant difference for late bilinguals in the F1 values of /o/ and /e/ ($p < .05$). The mid-vowels /o/ and /e/ for the late bilingual group were condensed, that is, /e/ was produced father back in the vowel space while /o/ was produced in a more fronted position. The F2 values of both /e/ and /o/ for the late bilingual group were statistically significant ($p < .05$) indicating that both groups of heritage speakers differed from the late bilingual group.

3 See Appendix A for statistical analyses results.

Vowel Production in Cognate vs. Non-Cognate Words

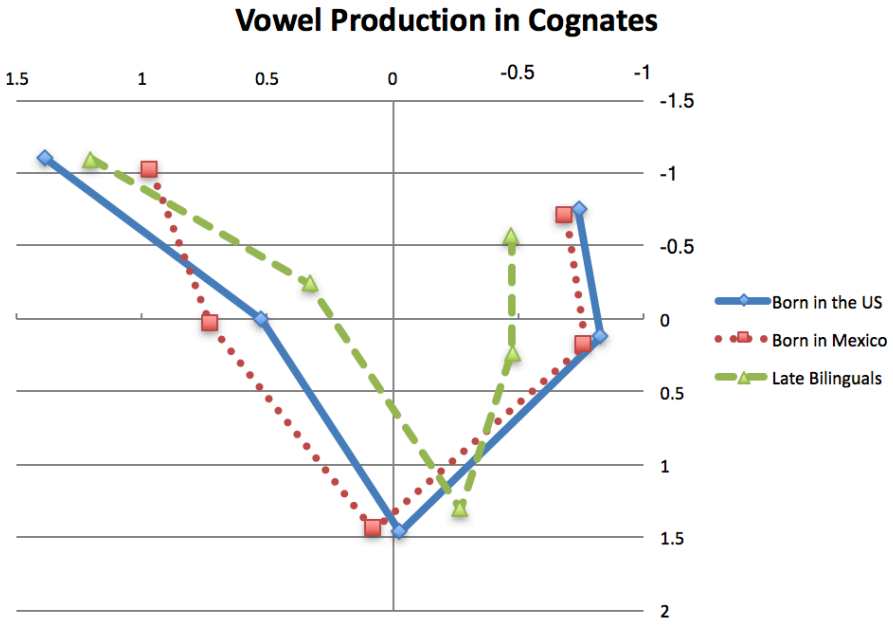

Figure 2. Vowel plot showing average normalized F1 and F2 values in Cognate words

Vowel production in cognate words for those born in the United States and those born in Mexico differs from that of late bilinguals (see Figure 2). The heritage speaker groups produced more often a fronted /e/ and /a/ (i.e., have higher F2 values) than the late bilinguals; however, this was not statistically significant. Those born in the US show a more fronted /i/ than their Mexican-born counterparts. Late bilinguals show a more fronted /u/ and /o/ with higher F2 values in comparison with the heritage speaker groups which appear to have visually similar values for the back vowels. Statistically significant differences occurred between the late bilingual group and the two heritage speaker groups for F2 values of the vowel /o/ ($p < .001$) as well as between the US born group, late bilinguals and the F2 values of /i/ ($p < .05$) Mexican born group. The /o/ for late bilinguals was significantly more fronted than the /o/ for heritage speakers. The Mexican born group produced /i/ farther back in the vowel space than those born in the United States and the late bilinguals.

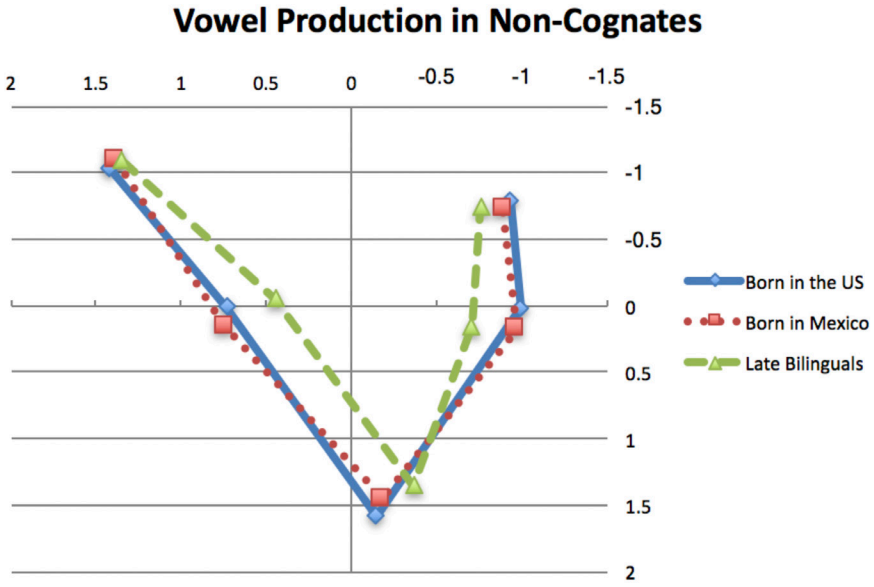

Figure 3. Vowel plot showing average normalized F1 and F2 values in Non-cognate words

In Figure 3, the heritage speaker groups show a more fronted /e/ and /a/ with higher F2 values than the late bilingual group which is similar to what was noted for vowels produced in cognate words. The front vowel /i/ appears to be similar across all three groups. Although the values for /u/ show some fronting, they are visually similar for all three groups. There appears to be slightly more fronting for the /o/ for late bilinguals.

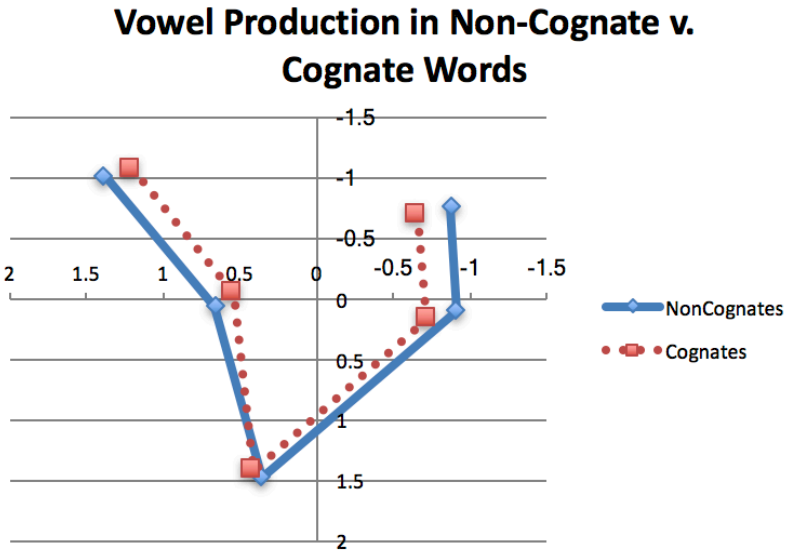

Figure 4. Vowel plot showing average normalized F1 and F2 values in Non-cognate and Cognate words

Figure 4 displays the vowel space for all groups in cognate and non-cognate words. The visual comparison shows that vowels in cognate words tend to reduce or condense more than those

in non-cognate words with the exception of /a/, which appears slightly more fronted in cognate words. Cognate status was a significant factor for all groups for the F1 values of /o/ and /e/ ($p < .001$ and $p < .05$ respectively). While the vowel /o/ was produced slightly lower in the vowel space (i.e. lower tongue position) for cognate words, the vowel /e/ was produced slightly higher. In regard to the front-back dimension (i.e., F2 values), cognate status was a significant factor for vowels /u, o, a, and e/. The back vowels /o/ and /u/ were more fronted in cognate words while the mid vowel /a/ and front vowel /e/ were produced farther back in the vowel space.

Stress

Lexical stress was included in the analysis to determine the role of stress in vowel quality in cognate and non-cognate words. Figure 5 presents the vowel space for all groups in cognate and non-cognate words for tonic and atonic vowels. The chart includes the average of all groups' normalized values as no significant differences were found between groups with the exception of the F1 values of /o/ for the late bilingual group. Statistical analyses reveal that the F1 values of /o/ for the late bilingual group showed marginal significance for the atonic values ($p = .043$). In addition, the interaction between cognate and atonic /o/ was found to be statistically significant ($p = .002$).

Unstressed vowels for late bilinguals were produced with lower F1 frequency measurements (i.e. higher) than stressed /o/. For all groups, unstressed /a/ was significantly different ($p < .001$) than stressed /a/ in both cognate and non-cognate words. F1 frequency measurements for stressed /a/ were greater than the F1 values of unstressed /a/. Unstressed /a/ for both groups was produced higher in the vowel space than stressed /a/ in cognate and non-cognate words. Along the F2 dimension, unstressed /u/ was significantly more fronted (higher F2 values) than its stressed counterpart ($p = .01$). Visual comparisons in Figure 5 reveal that atonic vowels in cognate words were produced more centrally in the vowel space in contrast with tonic vowels in cognate and non-cognate words and atonic vowels in non-cognate words. In general, the atonic vowels show greater reduction than their tonic counterparts.

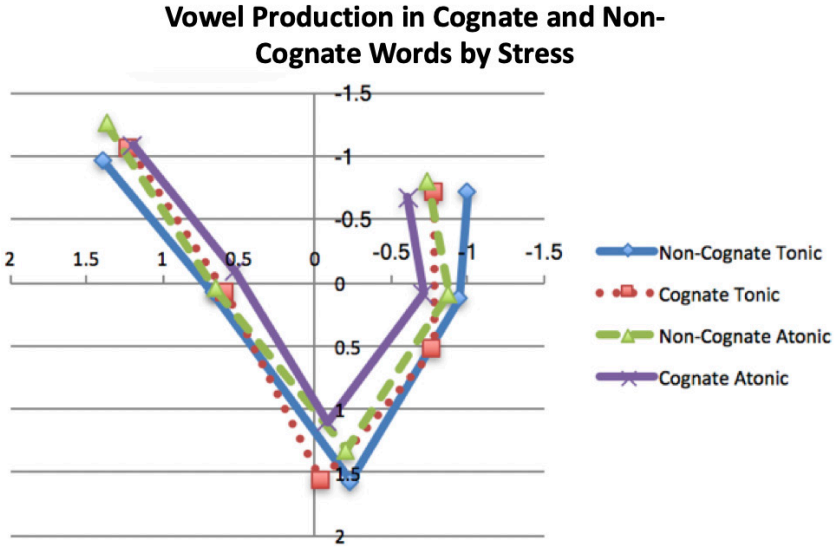

Figure 5. Vowel plot showing average normalized F1 and F2 values in Cognate and Non-Cognate words by Stress

5. Discussion

The current analysis of vowel production in the Spanish of heritage speakers in cognate and non-cognate words revealed that the vowel productions differ from traditional acoustic descriptions of monolingual varieties of Spanish (see Quilis and Esgueva, 1983). First, the acoustic space differs among monolinguals, heritage speakers and late bilinguals. Current analysis demonstrates that the heritage speakers and late bilinguals' vowel space is less symmetrical and less triangular than that of monolingual native speakers of Spanish, thus corroborating the findings of Willis, (2005), Boomershine, (2012), and Ronquest, (2012). However, it is difficult to generalize due to the smaller sample size. Nonetheless, this finding is in contrast with previous characterizations of the Spanish vowel system which argue that vowels remain in a simple, stable, symmetrical, five-vowel system (Hualde, 2005).

The vowel space of the heritage speakers in this study is visually like that described by Ronquest (2012) in that both show similarly asymmetrical vowel distributions with a condensed back vowel space and more open front vowel space. Fronting of the back vowel /u/ is also apparent in both cases. Statistical analyses revealed significant differences between the late bilinguals and the two heritage speaker groups with respect to the F2 dimension of vowels /o/ and /e/ although all three groups show similar asymmetrical vowel distribution like that found in Ronquest (2012). Late bilinguals produced a more fronted /o/ while /e/ was produced farther back in the vowel space. Despite these differences, heritage speaker groups and the late bilingual groups as a whole show similar patterns in their production of vowels.

In regard to cognate status, the results show that vowels in cognate words for all groups show greater reduction than those in non-cognate words and that this difference is statistically significant for the F1 values of /o/ and /e/ and the F2 values of /o, u, a, and e/. In addition, cognate status affected the F2 values of /i/ only for the Mexican born speakers. While it might be expected that vowels in cognate pairs that have a given mismatch (such as ob**e**dience vs. ob**e**diencia) may be produced with clearly distinct qualities, nearly all differences of vowel production were gradient, with the exception of one production of /u/ in the word "funeral" which was produced with the English /u/ by participant H2 in both the Spanish and English context. In line with the findings of Amengual (2012) these results reveal the cross-language phonetic influence for Spanish-English bilinguals' production of cognate words, providing further evidence that bilingual language systems operate alongside each other and not independently from one another. Flege (1995) highlights the idea of a shared phonetic space in his Speech Learning Model stating that if two sounds in the phonetic space share similar qualities, they may merge, showing features of the two assimilated sounds. Although L2 learners may eventually develop separate categories for the L2 sounds, they may still produce sounds that are different from monolinguals. The results in this study show that cognates induce a more reduced, centralized production of the vowels. However, it is difficult to determine if the productions here are a result of bilingualism (and the merging of the two systems) or if the asymmetry is a result in the shift of the monolingual production of vowels. Previous studies of monolingual Mexican Spanish vowels (see Poch Olivé, Harmegnies & Butragueño, 2008 and Butragueño, 2014) have shown a tendency for significant centralization of /i,e,o,u/ in spontaneous speech. Although speech style was not a factor in the current study and spontaneous speech was not collected, it may be that a similar shift occurred in the production of vowels to a more centralized position for monolingual Mexican speakers. However, the current study reveals a relatively less stable production of /a/ where monolingual Mexican Spanish speakers' production remained stable in both the spontaneous and "labora-

tory" speech tasks.

Taking into account lexical stress, the results show that heritage speaker groups and late bilinguals patterned similarly in their production of cognate and non-cognate words for tonic and atonic vowels. Late bilinguals and the heritage speaker groups produced more centralized vowels in atonic vowels in cognate words. In addition, atonic vowels in non-cognates were also more centralized in contrast to their tonic counterparts. Unstressed vowels for late bilinguals were produced with lower F1 frequency measurements than stressed /o/. Late bilinguals' F1 values for unstressed /o/ were significantly different than those produced by the heritage speaker groups while F1 values for unstressed /a/ were significantly lower than stressed /a/ in both non-cognate and cognate words for all groups. This suggests a more centralized production of vowels in unstressed position for /o/ and /a/. Although /a/ appears more centralized, it does not appear to be reduced in the direction of the English schwa [ ], similar to what was found in previous studies (see Ronquest, 2012). Speakers from all groups show a greater tendency to reduce or centralize vowels in unstressed position and in cognate words, although cognate status was not significant in terms of lexical stress. The lower F1 frequency measurements for /o/ and /a/ align with Ronquest's (2013) findings, showing that unstressed vowels /e/, /a/, and /o/ were produced higher in the vowel space (i.e. lower F1 values) than stressed /e/, /a/, and /o/. For the F2 dimension, unstressed /u/ was more fronted than stressed /u/, echoing the findings of Boomershine (2012), Ronquest (2012) and Willis (2005). Reduction and centralization in comparison to monolingual varieties of Spanish is not uncommon in previous investigations of heritage and bilingual vowels (see Alvord & Rogers, 2014; Boomershine, 2012; Ronquest, 2012, 2013; Willis, 2005).

All in all, further studies regarding the monolingual Spanish vowel system are required in order to determine if this asymmetry and centralization is truly a bilingual phenomenon or a shift in the monolingual production of vowels. It is quite possible that traditional descriptions of the monolingual Spanish vowel system are out-of-date. While future research should aim to shed more light on the current vowel system of monolingual Spanish, use of such monolingual comparison groups in research regarding bilingual Spanish speakers may obscure important details and phenomena that are unique to bilingual groups with varying learning experiences. Monolingual comparison groups may be necessary to determine possible effects of bilingualism on vowel production; however, by using bilingual comparison groups such as the late bilingual group used in the current study, differences and similarities among bilingual groups can be better understood.

6. Limitations

Several limitations in the current study should be acknowledged. First, although all speakers in this study identified as Mexican Spanish speakers, regional differences in language production cannot be ignored. As such, future research should incorporate comparison groups from the same regional variety. Secondly, there was an imbalance of vowels in stressed and unstressed position as cognate status was the sole factor in the development of materials for this study. Furthermore, although all vowels occurred word-medially, vowels immediately following or preceding certain consonants, such as /s/, can influence the vowel quality as noted by Lipski (2004; 2008). Nasalization may also play a role in the vowel quality and should be controlled in future research. Further studies should take into consideration and control for surrounding context as well as cognate status in conjunction with task formality. As Zampini (1994) and Colantoni, et al (2016) mention, task formality can have an effect on heritage speakers' realization of different

phonemes and pitch accents. That is, the level of literacy in each language may impact production and, as a result, less-controlled tasks may be better suited to capture the bilingual status of adult bilinguals in the United States (Colantoni, et al., p. 20). Based on this understanding, it is incumbent upon future research in this area to allow for the role of task formality on vowel production. In addition, further research should incorporate more speakers to allow for more generalizability in the results.

7. Conclusion

The current study examined the effect of cognate status on heritage speaker (i.e. early bilinguals) vowel production in comparison to late bilinguals' vowel production. Early bilinguals' and late bilinguals' vowel space is more constricted for the back vowels with a wider front vowel space. In addition, unstressed vowels in cognate words tended to be more centralized than unstressed vowels in non-cognate words. Vowels in cognate words showed the greatest reduction across groups, although the vowel space of all speaker groups demonstrates similar asymmetrical vowel distributions with a condensed back vowel space and more open front vowel space. The findings suggest that the vowel systems of early (i.e. heritage speakers) and late bilingual Spanish speakers may not be significantly different. Lastly, the acoustic and statistical analysis presented in this study have contributed to our understanding of the Spanish vowel system of heritage speakers specifically in regard to the effects of cognate status on vowel production. The differences in production of vowels in cognate and non-cognate words suggest that the bilingual phonetic inventories do not work independently from one another.

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Appendix A

Table A. 1
Summary of Linear Mixed-Effects Statistics for Models Predicting Normalized F1 Values

Vowel	n	Fixed Effects	ß	SE	*t*	*p*	Random effects	Variance	SD
/i/	203	Intercept	-.988	.100	-9.81	.000	Speaker	.01407	.1186
		Cognates	-.0906	.127	-.711	.476			
		MexBorn	-.0723	.148	-.487	.625			
		LateBilingual	.1467	.157	.932	.351			
		Stress(atonic)	-.2838	.170	-1.66	.095			
		Cognate:atonic	.2464	.172	1.43	.151			
		Cognates:MB	.1154	.180	.640	.521			
		Cognates:LB	-.0670	.195	-.343	.731			
		MB:atonic	.0660	.184	.357	.720			
		LB:atonic	-.0983	.199	-.493	.621			
/e/	246	Intercept	.0916	.061	1.48	.136	Speaker	.007539	.08683
		Cognates	-.1098	.054	-2.02	.043*			
		MexBorn	.0648	.086	.749	.453			
		LateBilingual	-.1867	.092	-2.02	.042*			
/a/	231	Intercept	1.695	.097	17.29	.000	Speaker	.01393	.118
		Cognates	-.0950	.082	-1.14	.250			
		MexBorn	-.0785	.125	-.623	.533			
		LateBilingual	-.1958	.132	-1.47	.140			
		Stress(atonic)	-.3538	.087	-4.06	.00*			
/o/	247	Intercept	.0299	.096	.309	.756	Speaker	.009446	.09719
		Cognates	.4092	.114	3.57	.000*			
		MexBorn	.3200	.136	.234	.814			
		LateBilingual	.3409	.148	2.29	.02*			
		Stress(atonic)	-.7161	.113	-.001	.999			
		Cognate:atonic	-4.139	.137	-3.01	.002*			
		MB:atonic	1.274	.148	.858	.390			
		LB:atonic	-3.226	.159	-2.01	.043*			

/u/	231	Intercept	-.727	.094	-7.73	.000	Speaker	.01773	.1332
		Cognates	-.0219	.101	-.216	.829			
		MexBorn	.0285	.135	.210	.833			
		LateBilingual	.0124	.147	.085	.932			
		Stress(atonic)	-.107	.095	-1.13	.257			
		Cognate:atonic	.1008	.105	.957	.338			
		Cognates:MB	.0030	.121	.025	.980			
		Cognates:LB	.1342	.128	1.046	.295			
		MB:atonic	.0427	.123	.346	.729			
		LB:atonic	.0568	.130	.434	.664			

*Significant variables are noted with an asterisk.

Table A. 2
Summary of Linear Mixed-Effects Statistics for Models Predicting Normalized F2 Values

Vowel	n	Fixed Effects	ß	SE	*t*	*p*	Random effects	Variance	SD
/ɪ/	203	Intercept	1.479	.183	8.08	.000	Speaker	.07843	.2801
		Cognates	.0636	.198	.320	.748			
		MexBorn	-.1188	.271	-.438	.661			
		LateBilingual	-.1675	.289	-.578	.562			
		Stress(atonic)	-.3037	.265	-1.14	.252			
		Cognate:atonic	.0241	.268	.090	.928			
		Cognates:MB	-.5515	.280	-1.96	.04*			
		Cognates:LB	-.2926	.304	-.959	.337			
		MB:atonic	.4425	.288	1.53	.124			
		LB:atonic	.4709	.311	1.51	.129			
/e/	246	Intercept	.6368	.088	7.18	.000	Speaker	.01043	.1021
		Cognates	-.1157	.056	-2.06	.03*			
		MexBorn	.0815	.089	.906	.364			
		LateBilingual	.1625	.133	1.22	.222			
		Stress(atonic)	-.0404	.136	-.296	.766			
		MB:atonic	-.0922	.138	-.667	.504			
		LB:atonic	-.3257	.141	-2.30	.021*			
/a/	231	Intercept	-.1636	.083	-1.95	.05	Speaker	.0245	.1566
		Cognates	.1518	.046	3.28	.001*			
		MexBorn	.0404	.118	.341	.732			
		LateBilingual	-.237	.127	-1.85	.063			
		Stress(atonic)	-.0126	.048	-.259	.795			

/o/	247	Intercept Cognates MexBorn LateBilingual	-1.006 .1894 .0431 .3189	.075 .067 .102 .109	-13.3 2.78 .421 2.90	.000 .005* .673 .003*	Speaker	.009096	.0953
/u/	231	Intercept Cognates MexBorn LateBilingual Stress(atonic)	-1.062 .1743 .0566 .2196 .2283	.131 .092 .173 .186 .094	-8.04 1.88 .326 1.17 2.42	.000 .05* .743 .239 .01*	Speaker	.04165	.2041

*Significant variables are noted with an asterisk.

Appendix B

1. Materials

Target Vowels are in Bold

Cognate Words

/e/

El corredor ganó una m**e**dalla de oro.

Se casaron en s**e**creto y nadie se enteró.

Debían jurar ob**e**diencia al Rey.

Desayuno c**e**real todos los días.

La mat**e**mática y la aritm**é**tica son muy difíciles para mí.

Estoy compl**e**tamente de acuerdo contigo.

El país declaró su ind**e**pendencia en 1776.

El estudiante tiene que pr**e**parar su proyecto para la clase.

Es una n**e**cesidad beber agua todos los días.

/a/

El m**a**pa de Argentina está al lado de la pizarra.

El pir**a**ta busca el tesoro en la isla.

Los científicos miran los pl**a**netas con los telescopios.

Una boda es una oc**a**sión especial y feliz.

Me gusta escuchar la r**a**dio mientras me preparo para clase.

Las pl**a**ntas necesitan mucha agua durante el verano.

El corredor ganó una med**a**lla de oro.

La ensalada lleva tom**a**te y lechuga.

En el rancho criaba vacas y cerdos.

La comida natural es buena para la salud.

/i/

La lista de comestibles es bastante larga.

Mi amigo estudia estadística en la Facultad de Ciencias.

Su fortuna llego al millón de dólares.

Me fascina la ciencia.

Ella no quiere insistir en trabajar porque está enferma.

El mejor animal del zoo es el chimpancé.

La azafata abrió la puerta de la cabina para hablar con los pilotos.

El comité decidió perdonar su mala conducta.

/o/

Su comida favorita es chocolate.

El hospital está al lado del río.

Es un honor trabajar con usted.

El contrato dice que no se puede trabajar más de 30 horas a la semana.

Me dolía el estómago después de comer la ensalada.

Hay muchas rocas grandes en la playa.

El problema no tiene solución.

No quiere continuar de esta manera.

La contribución de la comunidad fue clave para el éxito del jardín comunitario.

/u/

La comida natural es buena para la salud.

Ella lleva perfume todos los días.

Los humanos han habitado la tierra durante miles de años.

Él estaba furioso después de sacar mala nota en el examen.

La tarea era confusa y muy difícil de entender.

El trámite funeral es muy costoso.

Tengo que estudiar para el examen.

El Monumento de San Jacinto se construyó en 1939.

El tubo de escape del coche se ha perforado.

La introducción fue escrita por mi amiga Julia.

Non-cognate words

/a/

El pato cruzó la calle.

Cada vez que habla tiene una sonrisa. Está enamorado.

Él parece muy vago pero es muy trabajador.

Las camas de esa tienda son muy malas.

El teclado de mi computadora no funciona.

Tengo que levantarme temprano mañana.

/i/

Ella fue testigo del accidente.

La hija de Juan se llama Julia.

Su mamá fue a misa el viernes pasado.

Su hermano tuvo que hacer la misma tarea cuando él tomó el curso.

Él limpia el baño cada semana.

Ella prefiere leer el libro en la biblioteca.

Hay un nido en el árbol.

Cada vez que habla tiene una sonrisa. Está enamorado.

Dibujar con puntos es muy difícil.

/e/

Ponga la fruta en la mesa al lado de las verduras, por favor.

Ella prefiere comer la ternera para la cena.

Ella ganó una beca para estudiar en Chile.

Hay que beber mucha agua en el verano.

Me gustaría pedir la sopa del día para almuerzo.

Es una pena que él haya sacado una mala nota en el examen final.

El teclado de mi computadora no funciona.

Tengo que levantarme temprano mañana.

/o/

Tomó los papeles y se los llevó a casa.

Puso todas las cosas en la bolsa azul.

La boda de Julio y María era muy bonita y divertida.

El sol aparece antes por el este.

Se torció el tobillo al caer de la bicicleta.

Cada vez que habla tiene una sonrisa. Está enamorado.

/u/
El humo envolvía la casa durante el incendio.

A ella le gusta esc**u**char la música clásica.

Tienes que hacer el n**u**do bien fuerte para que no se desaten las cuerdas.

El hotel es muy l**u**joso y elegante.

Me gustaría probar la bl**u**sa azul, por favor.

La reunión t**u**vo lugar en la oficina del director.

Dib**u**jar con p**u**ntos es muy difícil.

El cartero s**u**bió por las escaleras.

Appendix C

Bilingual background questionnaire for Spanish/English speakers

Bilingual background questionnaire for Spanish/English speakers

(This information will be kept confidential)

Name: ___________________________ Age: ______________ Gender:______

Telephone number or e-mail:__________________________________

• •

I. Personal Data

What is your highest level of education completed? (please circle):

some high school high school some college college graduate

Country of origin: ____________________________________

Country of current residence:______________________________

1. If you were not born in the U.S., during what ages did you live in your country of origin?

2. If you were not born in the U.S., how long have you lived in the U.S. for?

3. How often do you visit your country of origin?

****

II. Family History

4. Where are your parents/caregivers from?

Mother: ________ Father:____________

5. What languages do your parents/caregivers speak?

Mother: ________ Father:____________

6. What do your parents do for a living?

Mother: ________ Father:____________

7. What is your parents' highest level of schooling? (circle one for each)

Mother		Father:	
	elementary school		elementary school
	Middle school		middle school
	High school		high school
	College		college
	Grad school		grad school

8. Where do your parents live?

9. How often do you speak with your family? How often do you talk to your brothers or sisters?

10. Do you have family that lives in the Twin Cities (or Nebraska)? If so, how often do you talk to them?

11. Do you have family members from your country of origin that visit you?

12. When was the last time someone from your country of origin visited you? How long did they stay?

13. Did any one of your family members move to the Twin Cities recently? How often do you talk to them? What languages do you speak with this person?

14. Does this contact influence you to use more Spanish?

****

III. Your Linguistic History

15. At what age did you first begin to learn English?

16. At what age did you first begin to learn Spanish?

17. Did you begin to speak both English and Spanish before age 5? (circle one)

Yes No

18. What languages did you hear in your home between the ages of birth-5 years? (circle all those that apply)

Spanish English Mixed Other (specify) _____

19. What languages did your parents/caregivers use mostly when speaking to you?

Spanish English Mixed Both Other

20. What languages did you use mostly when speaking to your parents/caregivers?

Spanish English Mixed Both Other

21. Do you have siblings?

Yes No how many? Are they older or younger?

22. What language/s did you use when speaking with your siblings?

Spanish English Mixed Both Other

23. What language/s did your siblings use when speaking with you?

Spanish English Mixed Both Other

24. Did grandparents live at home?

Yes No

25. What language/s did your grandparents use when speaking to you?

Spanish English Mixed Both Other

26. What language/s did you use when speaking with your grandparents?

Spanish English Mixed Both Other

27. Did you play with other Spanish-speaking children?

Yes No

28. What languages did you use with other children/siblings?

Spanish English Mixed Both Other

29. Did your parents encourage you to speak Spanish as much as possible in the house?

Yes No

30. Did your parents correct you when you spoke Spanish?

Yes No

****

IV. Elementary School

31. How often did you use Spanish between the ages 6-10?

always often seldom never

32. Who did you speak Spanish with?

mother/father siblings friends others

33. Did you attend elementary school in the US?

Yes No

34. Was English the primary language of instruction?

Yes No

V. Middle School

35. How often did you use Spanish between the ages 11-13?

always often seldom never

36. Who did you speak Spanish with?

mother/father siblings friends others

37. Did you attend middle school in the US?

Yes No

38. Was English the primary language of instruction?

Yes No

****

VI. High School

39. How often did you use Spanish between the ages 13-17?

always often seldom never

40. Who did you speak Spanish with?

mother/father siblings friends others

41. Did you attend high school in the US?

Yes No

42. Was English the language of instruction?

Yes No

****

VII. Young adult/University experience

43. How often did you use Spanish between the ages of 18-21?

always often seldom never

44. Who did you speak Spanish with?

mother/father siblings friends others

45. Did you attend university in the US?

Yes No

46. Was English the language of instruction?

Yes No

****

VIII. Current Language Use

47. If you were in the hospital, list the top five friends or family members who would visit you and what language they would speak with you.

1. Language:
2. Language:
3. Language:

4. Language:
5. Language:

48. Circle the answer that best completes the following statement: I am most comfortable when speaking...

English Spanish Both Other:

49. Do you prefer to use English or Spanish in your day-to-day routine where you live currently?

English Spanish

50. How often do you speak Spanish now? (circle one)

always often seldom never

51. How important is Spanish to you?

Extremely important very important moderately important slightly important not at all important

52. How important is English to you?

Extremely important very important moderately important slightly important not at all important

53. In what situations is it appropriate to use English? Please explain.

54. In what situations is it appropriate to use Spanish? Please explain.

****

XIV. Your linguistic proficiency now

55. Rate your current overall language ability in ENGLISH

1 = understand but cannot speak
2 = understand and can speak with great difficulty
3 = understand and speak but with some difficulty
4 = understand and speak comfortably, with little difficulty

5 = understand and speak fluently like a native speaker

56. Rate your current overall language ability in SPANISH

1 = understand but cannot speak
2 = understand and can speak with great difficulty
3 = understand and speak but with some difficulty
4 = understand and speak comfortably, with little difficulty
5 = understand and speak fluently/native speaker

57. On a scale from 1 to 5, rate your abilities in English and in Spanish
(1 =poor; 2= needs work; 3=good; 4= very good; 5= native speaker command)

English	Reading =	Speaking=	Listening=	Writing=
Spanish	Reading =	Speaking=	Listening=	Writing=

58. In general, as an adult, which language do you prefer to use? (circle one)

English	Spanish	It depends on whom I talk to	Both

59. Would you like to improve your English language skills?

Yes	No	Why?

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Modified from a questionnaire created by Dr. Silvina Montrul, University of Illinois at Urbana Champaign found at http://www.nhlrc.ucla.edu/data/questionnaires.asp.