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# The vowel spaces of Southern Californian English and Mexican Spanish as produced by monolinguals and bilinguals

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**2aSC44. The vowel spaces of Southern Californian English and Mexican Spanish as produced by monolinguals and bilinguals**

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The vowel spaces of Southern Californian English and Mexican Spanish were investigated using three groups of speakers: 11 English monolinguals (9 female), 10 Spanish monolinguals (7 female), and 11 Spanish-English bilinguals (8 female). Speakers produced six repetitions of the ten American English vowels [i, ɪ, ε, æ, ɑ, ɔ, ʊ, u, ʌ, and ɜr] and six repetitions of the five Spanish vowels [i, e, a, u, and o]. Monolinguals produced vowels in one language; bilinguals produced vowels in both languages. Preliminary analysis shows for females Southern Californian English back vowels were less fronted compared to the results of Hagiwara (1997) from Southern Californian English, but more fronted than those of Hillenbrand et al. (1995) on General American English. Mexican Spanish back vowels [u] and [o] were substantially backed compared to Castilian Spanish vowels (Bradlow, 1995), while [i] was lower and more fronted. In general, Mexican Spanish vowels were produced more backed than Southern Californian English vowels in monolingual productions. Bilinguals produced their two vowel spaces with Spanish more backed and lower as compared to English.

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## INTRODUCTION

Research on vowel spaces has sometimes been conducted without sufficient consideration of the dialect and language background of the participants. For instance, in the original Peterson and Barney (1952) study of English vowels, the participants were described as speakers of “General American” with very few other details about their backgrounds. Since then researchers have better specified the dialect of their speakers when analyzing vowel spaces. For example, Hillenbrand et al. (1995) replicating Peterson and Barney (1952) noted that the majority of their speakers were from Michigan’s lower peninsula and the rest from various states in the Midwest. Few studies, however, have focused on specific American dialects other than “General American.” One exception is Hagiwara (1997), who examined Southern California vowel spaces and ended his paper calling for more work on dialectal differences and updated studies to document dialectal change over time. More recently Aiello (2010) compared Northern and Southern California vowel spaces to examine differences between the two halves of the state.

Another language with a considerable number of dialects and few studies comparing them in regards to vowels is Spanish. One of the few vowel studies to specify the dialect of Spanish used is Bradlow (1995) who examined Madrid Spanish. Other than that most studies of Spanish have either lumped all speakers together across dialects, or neglected to clearly state which dialect was under investigation. To have a better picture of how Spanish dialects differ from each other more research on specific dialects is needed.

In addition to dialectal differences vowel studies would also benefit from taking into consideration the language background of the speakers. One particular aspect of their background that has been known to affect phonetic categories is bilingualism (see e.g. Flege & Eefting, 1987, on voice onset time). While bilinguals are still able to maintain two distinct categories for each language, they do not always perfectly match their monolingual counterparts. Bilingualism can thus also play a role in vowel production, even if both languages were learned at an early age (Baker & Trofimovich, 2005; Mora & Nadeu, 2012).

The present study looks at the vowels of specific dialects of English and Spanish, Southern California English and Border Spanish (Mexican Spanish as spoken in the San Diego-Tijuana border region). Within each dialect two populations are examined, monolingual and bilingual speakers. This allows us to examine how vowels differ between these specific dialects, as well as how bilingualism may have affected the vowel spaces of the bilingual speakers as compared to monolingual controls. The English data are also compared to Hillenbrand et al. (1995) and Hagiwara (1997) to examine the extent to which Southern California English vowels differ from General American vowels and how they have changed since Hagiwara’s study. Similarly, the Spanish data are compared to those of Bradlow (1995) to provide a preliminary documentation of differences between the Peninsular and Mexican vowels.

## METHOD

### Speakers

At present, data has been collected from three groups of speakers: eleven Southern Californian English monolinguals (nine female), ten Mexican Spanish monolinguals (seven female), and eleven Southern Californian English/Mexican Spanish bilinguals (eight female). Here we present data from five female speakers from each of the three groups.

Bilingual and monolingual English speakers were college students at the University of California, San Diego (UCSD). Monolingual Spanish speakers were college students at Universidad Autónoma de Baja California. Speakers from UCSD were given class credit for participating in the study. Speakers from Universidad Autónoma de Baja California received \$110 pesos in compensation for their time and travel. Speakers’ ages ranged from 19 to 23. The average age was 22 for monolingual English speakers, and 21 for monolingual Spanish and bilingual English-Spanish speakers. The bilingual speakers were either early sequential or simultaneous bilinguals; the average age of acquisition was 6 for both English and Spanish.

### Materials

The materials consisted of English and Spanish test words embedded in carrier phrases. The English carrier phrase was *Say \_\_\_ one more time* and the Spanish carrier phrase was *Repite \_\_\_ con cuidado*. The English test words were all monosyllabic and thus the test vowels carried stress. Spanish words consisted of two syllables with the test vowel always in the first. In addition, the Spanish materials included both words with stress on the first and

words with stress the second syllable (e.g. *paso* vs. *pasó*), so that the influence of stress on the Spanish vowels could be investigated (since Spanish uses the same vowels in both stressed and unstressed positions). This was not possible to achieve for all the Spanish diphthongs; thus for /ei/ only an unstressed variant was used, while for /au/, /oi/ and /ou/ only stressed variants were used (see Table 1).

Due to differences between the two languages it was not possible for the contexts to be identical, but overall the test vowels were preceded by a bilabial stop (/b/ in English and /p/ in Spanish) followed by a coronal consonant, /d/ in English and /s/ in Spanish. The full list of test words is shown in Table 1. Here we report only on the stressed versions of the five vowels that are most closely matched in English and Spanish: /i/ as in English *bead*, Spanish *piso*; /e/ as in English *bade*, Spanish *peso*; /a/ as in English *bod/bawd*,<sup>1</sup> Spanish *paso*, /o/ as in English *bode*, Spanish *poso*, and /u/ as in English *booed*, Spanish *puso*.

**TABLE 1.** Test words for English and Spanish. In the Spanish materials, the test vowel is underlined, while words with unstressed test vowels are in parentheses next to the stressed variant (where available).

<b>English</b>	monophthongs	<i>bead, bid, bade, bed, bad, bud, bod, bawd, bode, hud,</i> <sup>2</sup> <i>booed, bird</i>
	diphthongs	<i>bide, bowed, boyd</i>
<b>Spanish</b>	monophthongs	<i>p<u>i</u>so (p<u>i</u>só), p<u>e</u>so (p<u>e</u>só), p<u>a</u>so (p<u>a</u>só), p<u>o</u>so (p<u>o</u>ser), p<u>u</u>so (p<u>u</u>símos)</i>
	diphthongs	<i>(p<u>e</u>inar), p<u>a</u>is (p<u>a</u>isaje), p<u>a</u>usa, n<u>e</u>utro (n<u>e</u>utral), M<u>o</u>ises, m<u>o</u>usse</i>

## Procedure

Monolingual English and bilingual English and Spanish recordings were made in the sound-attenuated booth of UCSD's Speech Lab using an A-to-D converter. Speakers were recorded at a sampling rate of 48 kHz and 16-bit quantization. Monolingual Spanish recordings were made in a quiet room, using a Yeti microphone connected to a MacBook; the microphone was set to cardioid, and the sampling rate was 44.1 kHz.

Speakers were told that their task was to read aloud sentences while being recorded. They were shown the sentences in advance. Bilingual speakers in particular were told in advance that their participation consisted of two recordings, one in Spanish and one in English. The order of the two languages was counterbalanced, with three speakers starting with English and two starting with Spanish. At the end of the first recording, bilingual speakers were asked to build a jigsaw puzzle before proceeding to the second recording. The aim of the non-linguistic task between recordings was to minimize the influence of the first recorded language onto the second. At the end of the recording, all speakers were asked to fill out a language background questionnaire.

## Measurements

Test vowels were segmented in Praat using the TextGrid annotation function and simultaneous inspection of spectrograms and waveforms. The onset of the vowel was defined as the onset of full formant structure in the spectrogram (i.e. vowel duration did not include voice onset time). The lack of clear formant structure was used to determine the offset of the vowel together with the cessation of periodicity (the latter was used when the vowel was followed by /s/). F1, F2, and duration were extracted using a Praat script. For F1 and F2 measurements were taken at the midpoint of the vowel using the facilities of Praat. F1 × F2 scatterplots were made for each speaker to check for outliers due to possible errors in tracking; outliers were manually checked and values corrected as appropriate.

## Statistical Analysis

Linear mixed effects models were used to statistically test for differences between (i) monolinguals in each language (English monolinguals versus Spanish monolinguals), (ii) the production of bilinguals in their two languages (bilinguals speaking in English versus bilinguals speaking in Spanish), and (iii) monolinguals versus bilinguals in each language (English monolinguals versus bilinguals speaking in English; Spanish monolinguals versus bilinguals speaking in Spanish). For all models F1 in Hz, F2 in Hz, or duration in milliseconds was the dependent variable. Language (English or Spanish) or speaker language background (monolingual or bilingual) was

<sup>1</sup> Southern Californian English does not make a distinction between *bod* and *bawd* using instead a low back vowel close to /a/ for both (Hagiwara 1997; Ladefoged & Johnson, 2011, ch. 4); we included both words for completeness and maximum comparability with previous studies; we use the symbol /a/ to refer to this vowel in order to simplify comparisons with Spanish.

<sup>2</sup> The acronym *hud* was inadvertently used instead of *hood* to elicit /ʊ/, thus our corpus does not include data for /ʊ/; according to Hagiwara, /ʊ/ and /ʌ/ are merging in Southern Californian English.

the independent variable depending on the comparison under investigation. Speaker was included as a random effect. Significance was set to a  $p$  value of 0.05. All statistics were done in the statistical program R with the packages `languageR` and `lme4` (Baayen, 2007; Bates, 2007). Plots were made with the R package `vowels` (Kendall & Thomas, 2010).

## RESULTS

Average formant values and standard deviations for all speaker groups are presented in Table 2. Average durations are presented in Table 3.

**TABLE 2.** Average formant values in Hz for F1 and F2 separated by group and language. Standard deviations are in parentheses.

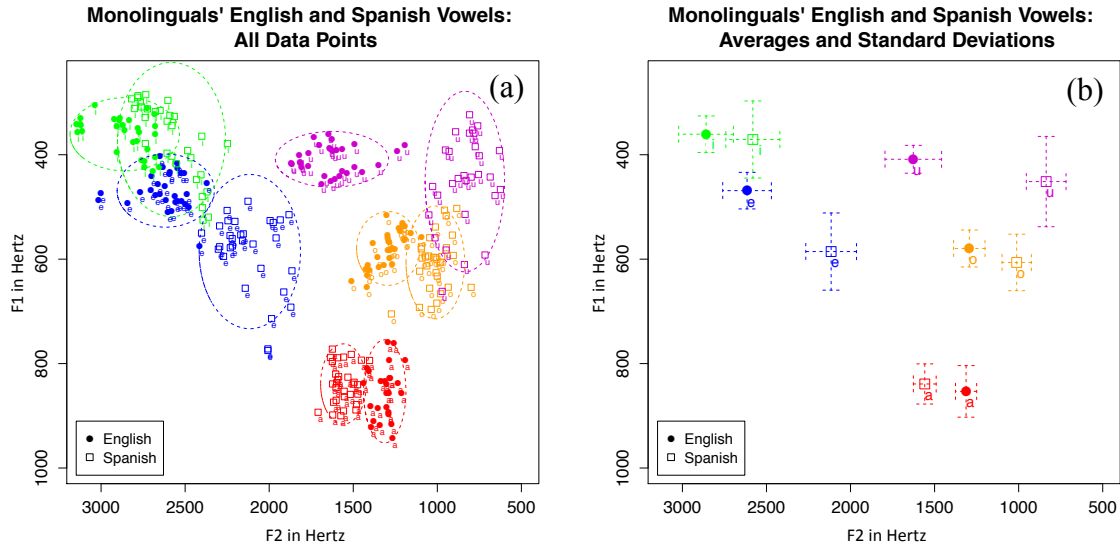
	Monolinguals				Bilinguals			
	English		Spanish		English		Spanish	
	F1	F2	F1	F2	F1	F2	F1	F2
i	361 (35)	2859 (163)	371 (74)	2581 (161)	366 (37)	2727 (192)	356 (32)	2640 (206)
e	469 (35)	2615 (145)	585 (74)	2115 (151)	424 (23)	2594 (194)	582 (36)	1980 (123)
a	853 (49)	1313 (63)	839 (38)	1558 (68)	776 (67)	1197 (80)	827 (60)	1455 (118)
o	580 (35)	1293 (93)	606 (54)	1012 (87)	529 (34)	1136 (136)	518 (45)	945 (41)
u	409 (27)	1627 (168)	451 (87)	836 (118)	392 (19)	1299 (246)	408 (26)	947 (142)

**TABLE 3.** Average durations in milliseconds separated by language and group. Standard deviations are in parentheses.

	Monolinguals		Bilinguals	
	English	Spanish	English	Spanish
	i	160 (31)	108 (20)	173 (28)
e	192 (31)	120 (17)	210 (27)	104 (24)
a	199 (32)	126 (14)	201 (19)	122 (26)
o	188 (31)	132 (18)	204 (25)	111 (25)
u	179 (35)	112 (18)	197 (31)	97 (30)

### Monolinguals

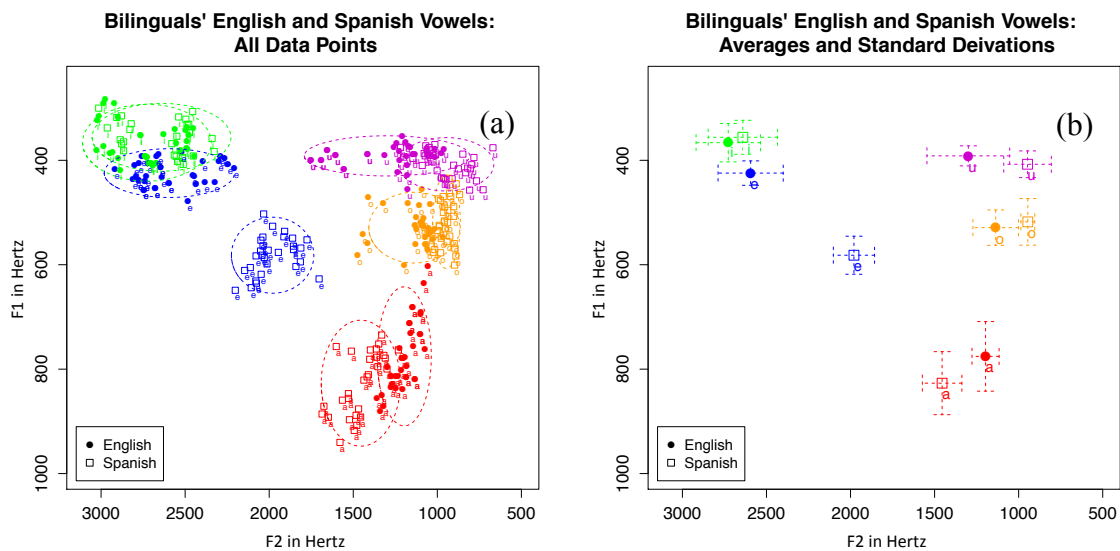
Formant frequency plots of all data points for each speaker and averages across speakers are in Figures 1(a) and (b). As F2 values suggest, monolingual Spanish speakers produced /i/, /o/ and /u/ significantly more backed than monolingual English speakers, [for /i/,  $t = -2.82$ ,  $p < 0.001$ ; for /o/,  $t = -7.26$ ,  $p < 0.001$ ; for /u/,  $t = -10.18$ ,  $p < 0.001$ ]. In addition, Spanish speakers produced /e/ significantly lower and more backed than English speakers [F1:  $t = 3.50$ ,  $p < 0.001$ ; F2:  $t = -5.92$ ,  $p < 0.01$ ], while they produced /a/ significantly more fronted than English speakers [F2:  $t = 6.58$ ,  $p < 0.001$ ]. Finally, as shown in Table 3, Spanish vowels were always shorter than English vowels [/i/:  $t = -3.36$ ,  $p < 0.001$ ; /e/:  $t = -6.14$ ,  $p < 0.001$ ; /a/:  $t = -6.38$ ,  $p < 0.001$ ; /o/:  $t = -3.97$ ,  $p < 0.001$ ; /u/:  $t = -4.92$ ,  $p < 0.001$ ].



**FIGURE 1.** In (a),  $F1 \times F2$  plots for all monolingual speakers for the vowels common to English and Spanish and ellipses of two standard deviations; in (b) average formant values for each vowel in each language; error bars represent one standard deviation.

## Bilinguals

Plots of all data points for each speaker and averages across speakers are shown in Figures 2(a) and (b). Bilinguals when speaking in Spanish produced /i/ and /o/ significantly more backed than when speaking in English [for /i/,  $t = -5.43$ ,  $p < 0.001$ ; for /o/  $t = -9.86$ ,  $p < 0.001$ ]. Both Spanish /e/ and /u/ were produced significantly lower and more backed than in English [for /e/,  $F1: t = 23.55$ ,  $p < 0.001$ ;  $F2: -23.17$ ,  $p < 0.001$ ; for /u/  $F1: t = 4.90$ ,  $p < 0.001$ ;  $F2: t = -7.59$ ,  $p < 0.001$ ]. Finally, Spanish /a/ was produced significantly lower and more fronted than in English [ $F1: t = -8.52$ ,  $p < 0.001$ ;  $F2: t = 12.32$ ,  $p < 0.001$ ]. In addition, as shown in Table 3, bilinguals produced Spanish vowels with significantly shorter durations than English vowels [/i/:  $t = -18.43$ ,  $p < 0.001$ ; /e/:  $t = -28.82$ ,  $p < 0.001$ ; /a/:  $t = -20.27$ ,  $p < 0.001$ ; /o/:  $t = -25.45$ ,  $p < 0.001$ ; /u/:  $t = -22.55$ ,  $p < 0.001$ ].



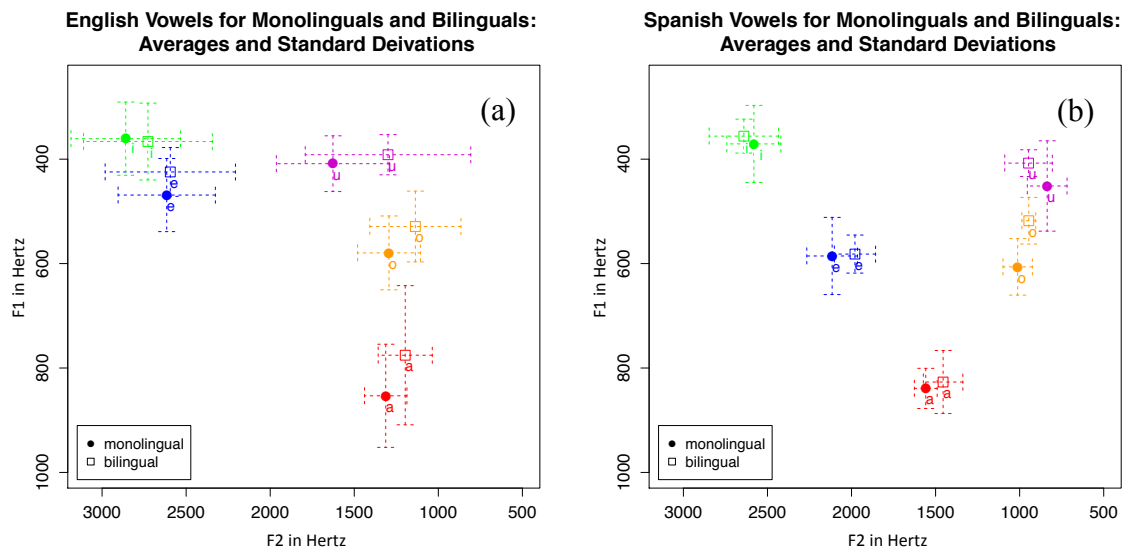
**FIGURE 2.** In (a),  $F1 \times F2$  plots for all bilingual speakers for the vowels common to English and Spanish and ellipses of two standard deviations; in (b) average formant values for each vowel in each language; error bars represent one standard deviation.

## Monolinguals vs. Bilinguals

Figures 3(a) and (b) show the vowel plots with averages and standard deviations for monolinguals versus bilinguals in both English and Spanish respectively.

The comparison of English monolinguals and bilinguals speaking in English showed that bilinguals produced /i/ significantly more backed than monolinguals [F2:  $t = -1.03$ ,  $p < 0.05$ ]. Bilinguals also produced /e/ significantly higher than monolinguals [F1:  $t = -3.04$ ,  $p < 0.001$ ], while their /a/, /o/ and /u/ were significantly higher and more backed than those of monolingual speakers [for /a/, F1:  $t = -2.35$ ,  $p < 0.001$ ; F2:  $t = -2.34$ ,  $p < 0.001$ ; for /o/ F1:  $t = -3.07$ ,  $p < 0.001$ , F2:  $t = -2.25$ ,  $p < 0.001$ ; for /u/, F1:  $t = -1.33$ ,  $p < 0.05$ ; F2:  $t = -3.37$ ,  $p < 0.001$ ]. Regarding duration, there were no significant differences between monolinguals and bilinguals for any of the vowels.

The comparison of Spanish monolinguals and bilinguals speaking in Spanish showed that bilinguals did not produce /i/ significantly differently from monolinguals in regards to either height or backness. On the other hand, bilinguals produced /e/ and /a/ significantly more backed than monolinguals [for /e/, F2:  $t = -1.70$ ,  $p < 0.01$ ; for /a/, F2:  $t = -1.73$ ,  $p < 0.01$ ]. In addition, bilinguals produced /o/ significantly higher and more backed than monolinguals [F1:  $t = -3.51$ ,  $p < 0.001$ , F2:  $t = -3.76$ ,  $p < 0.01$ ], while their /u/ was significantly fronted compared to that of monolinguals [F2:  $t = 1.59$ ,  $p < 0.05$ ]. Regarding duration, the only significant difference between the two groups was that bilinguals produced /o/ with shorter durations than monolinguals [ $t = -1.59$ ,  $p < 0.05$ ].



**FIGURE 3.** In (a), average F1  $\times$  F2 plots for monolingual English speakers and bilinguals speaking English, error bars represent one standard deviation; in (b), average F1  $\times$  F2 plots for monolingual Spanish speakers and bilinguals speaking Spanish, error bars represent one standard deviation.

## DISCUSSION

The present study had three goals. The first was to investigate differences between English and Spanish vowel spaces for two specific dialects as produced by monolingual speakers. The results revealed a general backing of the vowel space for Spanish with the exception of /a/ which was produced more fronted in Spanish than English. This is not surprising given that the Spanish vowel is often described as central (see e.g. Ladefoged & Johnson, ch. 9 and references therein) while the English equivalent is described as a low back vowel (e.g. Ladefoged & Johnson 2011). In terms of height, the only difference concerned /e/ which was significantly lower in Spanish than English. For all vowels Spanish had shorter durations than English, a result that agrees with general speaking rate differences between the two languages (among many, Pellegrino, Coupé & Marsico, 2011).

The second goal of the study was to compare the productions of monolingual and bilingual speakers in order to test the general claim that bilinguals tend to produce tokens that are close to the phonetic categories of each of their languages but not quite the same with either. The present results support this general idea. In comparing across their two languages bilinguals behaved very similar to monolinguals, with shorter durations for their Spanish than English vowels and a general backing of the vowel space for Spanish except for /a/ which was produced more fronted in

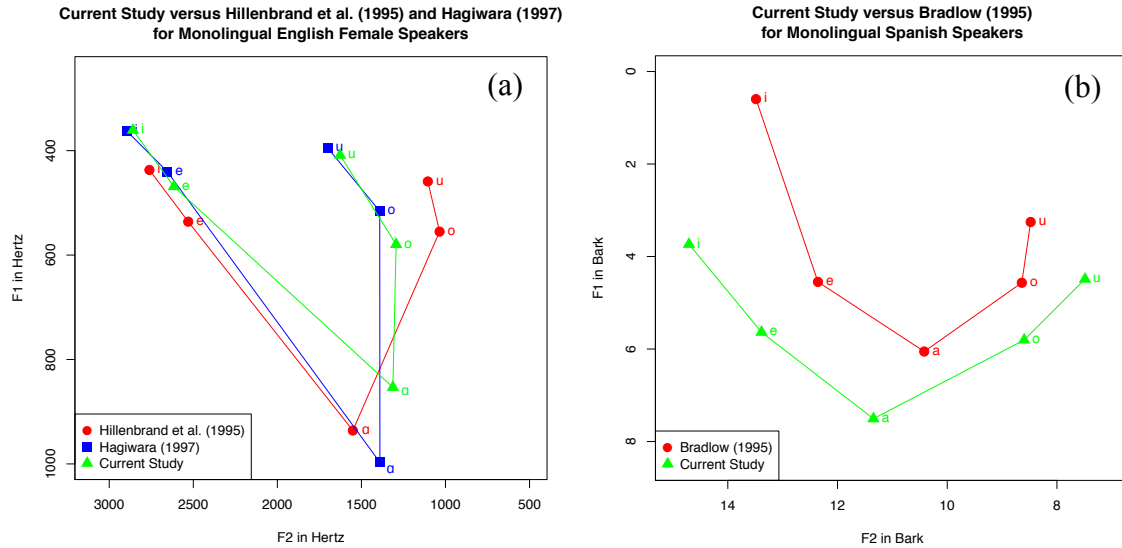


Spanish than English. Like their monolingual counterparts /e/ was produced lower in Spanish. Unlike the monolinguals, however, bilinguals produced Spanish /a/ and /u/ with qualities lower than those found in monolingual Spanish, suggesting that for bilinguals there is both a backing and lowering of the vowel space when speaking Spanish.

When monolinguals and bilinguals were directly compared within each language, bilinguals were found to produce their vowels more backed in both English and Spanish. For English the only vowel bilinguals did not produce significantly more backed than English monolinguals was /e/. This difference between monolingual and bilingual speakers is likely an effect of bilingualism. Specifically, the English productions of bilinguals were likely influenced by the fact that the Spanish vowel space is overall more back than the English vowel space (in the varieties investigated here at least), a difference that resulted in a more back vowel space for their English as compared to that of monolingual English speakers. The reverse, i.e. an influence of English on the Spanish of bilingual speakers is also observed, though it is more limited. Specifically, the Spanish /u/ of bilingual speakers was significantly more fronted than that of monolingual Spanish speakers. Southern Californian speakers of English have been known to front /u/ (Hagiwara, 1997; Ladefoged & Johnson, 2011, ch. 9) and this tendency may be resulting in a more fronted /u/ in the Spanish of bilinguals as well. However, as noted, the influence of English on the Spanish of bilingual speakers was rather limited: e.g. a general effect of English on Spanish would have resulted in the fronting of all Spanish vowels as compared to those of monolingual Spanish speakers, but our bilingual speakers produced three of their Spanish vowels (e/, /a/, and /o/) with more backing than their monolingual counterparts. Finally, there was also a consistent difference in height between monolinguals and bilinguals for English, with bilinguals producing all vowels except /i/ higher. Recall that bilinguals were also more likely than monolinguals to use the height as a dimension of difference between English and Spanish. Perhaps the increased height of English vowels is due to an attempt by bilinguals to enhance the difference between their English and Spanish vowels by using the height dimension, a difference not consistently found between the two monolingual groups.

The final goal of the study was to provide more information about two dialects and compare them to past studies. Focusing on the English results, Figure 4(a) shows how the present study differs from both Hillenbrand et al. (1995)'s study on General American English and Hagiwara (1997)'s study on Southern California English. Hagiwara found that Southern Californian English showed general fronting of back vowels as compared to Hillenbrand et al. (1995) as well as some backing of front vowels. Looking only at monolingual speakers the present study replicates some of Hagiwara's findings but also indicates that some changes may be taking place in Southern Californian English. While /o/ and /u/ continue to be more fronted than in General American there is also a lowering, particularly for /o/, and a raising and backing of /a/ compared to Hagiwara. Future analysis will include more vowels to see how the present study compares to past work on American English in general and the Californian variety in particular.

A preliminary comparison for Spanish was also conducting, comparing monolingual Spanish speakers in the present study to speakers from Bradlow (1995); Figure 4(b) shows this comparison. The comparison is less informative as the English comparison as Bradlow (1995) only included male speakers and the current study presently only includes female speakers. However, it does appear that differences between vowels are not the same for each vowel. For example, the /i/ vowel in the present study is produced lower as compared to Bradlow (1995) to a greater degree than other vowels. Furthermore, in the present study the range for F2 is larger than Bradlow (1995) suggesting that Mexican Spanish uses the backness dimension to differentiate vowels to a greater extent than Peninsular Spanish. Future work will include analyzing male speakers in Mexican Spanish to allow for a more direct comparison of the two studies.



**FIGURE 4.** In (a)  $F1 \times F2$  plots compare the present study's monolingual English speakers with female speakers from both Hillenbrand et al. (1995)'s study on General American English and Hagiwara (1997)'s study on Southern California English; in (b)  $F1 \times F2$  plots compare the current study's monolingual Spanish speakers to Bradlow (1995); a Bark transform was done on this data set since Bradlow (1995) only included male speakers and the current study only includes female speakers.

## CONCLUSION

This study adds to the growing research in dialectal variation and provides us with descriptive information about dialects of English and Spanish. It also allows us to learn more about how bilingual speakers compare to monolingual speakers. Future work will include an analysis of the full vowel inventories of each language. Additional analyses will also include male speakers, both allowing us to examine potential gender differences and additional comparisons to past studies.

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