Dialect Differences and the Bilingual Vowel Space in Peruvian Spanish

Erin O'Rourke
University of Pittsburgh

1. Introduction

The quality of Spanish vowels is often described as being relatively stable across Spanish dialects compared to consonants. Quilis & Esgueva (1983) examined vowels in several varieties of Spanish in order to derive a composite description of Spanish vowel quality. Recent laboratory work by Morrison & Escudero (2007) further supports this view. Comparing vowels produced by male and female speakers from Madrid and Lima, significant differences in formant values were not found between the two dialects (with the exception of the second formant (F2) of the vowel /o/). However, Peninsular speakers did employ significantly longer vowel sequences than the Peruvian speakers.

Shifts in vowel quality, nonetheless, are observed in a number of contexts. For example, Oliver (2007) observes word-final vowel raising of mid to high vowels (/e/>[i] and /o/>[u]) in Puerto Rican Spanish, a phenomenon also observed in Mexican and Peninsular varieties. In addition, mid vowels in hiatus are raised in diphthong formation ([e.o]>[jo]), for example in Colombian Spanish (Garrido 2007). In Andean Spanish, Delforge (2008) finds that unstressed vowels undergo devoicing as opposed to centralization. Willis (2008) also shows mid-vowel variation in Dominican Spanish, especially with atonic vowels, such that vowels /e/ and /o/ are not equidistant from /i/-/a/-/u/ in the vowel space but rather tend to overlap with the neighboring high vowels. In these examples, the vowel being altered is an unstressed vowel. In addition, Quilis (1993:170-178) describes a number of vowel-related phenomena found in different Spanish dialects, including instability in vowel quality, vowel deletion, labialization and vowel-laxing in word-final position.

In cases of language contact, the stressed vowel itself may exhibit a distinct vowel quality. Guion (2003) compared the vowels produced by Ecuadorian Spanish and Quichua bilinguals and found a target-like five-vowel system to be more common with simultaneous, early and some mid bilinguals, compared to a three-vowel system produced by late bilinguals and some mid bilinguals. Acquisition research by Flege, Bohn & Jang (1997) showed that a speaker's first language (L1) affected production and perception of English as a second language (L2) and that these affects were experience-dependent. Likewise, Baker & Trofimovich (2005) found for English and Korean speakers that the L2 vowels of late bilinguals were influenced by the L1 system, while the influence was bidirectional for early bilinguals. Chen (2007) also found L1 influence in vowel quality for Mandarin Chinese speakers learning Spanish. Last, in a study of Southwest Spanish speakers, Willis (2005) demonstrates regional vowel variation in a contact situation: the /a/ was found to be farther forward, similar to the /æ/ in English, the back vowels /o, u/ were lower and the /u/ also more forward than previous descriptions of Mexican Spanish.

In a similar approach, the present study of Peruvian Spanish provides a comparison between monolinguals of two different dialects, Lima and Cuzco, as well as a comparison between Quechua-

* This paper has benefited from audience feedback at the *4th Laboratory Approaches to Spanish Phonology* conference held in the University of Texas at Austin, and from presentations at the University of Illinois at Chicago and Indiana University, Bloomington. However, any error in content or analysis remains the sole responsibility of the present author.

 Selected Proceedings of the 4th Conference on Laboratory Approaches to Spanish Phonology, ed. Marta Ortega-Llebaria, 20-30. Somerville, MA: Cascadilla Proceedings Project.

Spanish bilinguals who learned both languages in the home (termed here Cuzco native bilinguals) and those who learned Spanish only after entering the school system (termed here Cuzco L2 Spanish speakers). The distribution of the vowel space is potentially different between languages in that while Spanish has five vowel phonemes /i, e, a, o, u/, Quechua is described as a having three vowel phonemes /i, a, u/ with mid vowels as allophonic variants appearing in the context of uvulars, e.g., [kusa] 'happy' vs. [qosa] 'husband' (Cerrón-Palomino 1994).[1] The difference in vowel production and perception is evident in the use of the term 'motosidad' to characterize Quechua-accented speech in which the mid and high vowels are mixed in Spanish (e.g., [pilu] for *pelo* 'hair') (1994:45-46). Early evidence for such mixing can be found in colonial court documents written by Quechua-Spanish bilinguals (Rivarola 2000). Lipski (1994:321) notes that this neutralization between high and mid vowels is highly stigmatized, such that this behavior may serve as a social marker between groups since it appears at or above the level of awareness.

The aim of the present study is to examine acoustic data in order to address the following research questions: (1) To what extent are regional differences observed in Peruvian Spanish vowels?, (2) Within the Andean region, are there differences in vowel quality according to knowledge of Quechua?, and if so, (3) Do Quechua-Spanish bilinguals organize their vowel space differently than Spanish monolinguals (e.g., in terms of spacing between vowel qualities or backness)? In a cross-linguistic analysis, Bradlow (1995) found English, an 11-vowel system, to occupy the same area as Spanish and Greek, both with 5-vowel systems when examining vowels in open syllables. However, Spanish and Greek still differed according to the location of formant values, with Spanish vowels being lower and farther front, suggesting a difference in 'base-of-articulation.' Therefore, in addition to potential differences in shape and size of the vowel space, the relative location of the vowel triangle will be noted.

The remainder of this paper is organized as follows: in section 2 methodology is presented, section 3 includes an overview of the results, section 4 provides a statistical analysis of the data, and section 5 gives a summary of the main research findings.

2. Methodology

2.1. Data set

The data are taken from a read corpus of utterances that were part of a sentence elicitation task designed for a separate study on intonation.[2] Participants were given a set of index cards with questions and answers written on them. The cards were read once and then a second time in reverse order. From these utterances, words containing stressed vowels in open syllables were extracted. The database for this pilot study consists of 672 vowels (28 tokens x 2 productions x 12 speakers).[3] In order to avoid segmentation difficulties, only monophthongs were included; also, words with a palatal segment preceding or following the vowel were not used. A minimum of 10 tokens per vowel were measured for each speaker. All words had penultimate stress (e.g., ˈ*vino*, *cer*ˈ*veza*, *ba*ˈ*nana*, *per*ˈ*sonas*) except for tokens with /u/, which had antepenultimate stress.[4]

---

[1] See Escobar (1978) for a description of the stages of acquisition of Spanish vowels by Quechua speakers.

[2] For the intonation study, each participant was shown an index card that included a grid with the name of a person in the first column, the number of an apartment in the second column, marital status in the third column, the name of a product in the fourth column, and the name of a drink in the fifth column. The participant was asked to answer a series of questions based on the information on the card, such as where the person lived, what he or she sold or what the person's favorite drink was. In preliminary testing participants were only given the questions and used the card to construct the answers. However, since participants sometimes gave one-word answers, the task was modified so that both the question and the related answer were written on the index card. The index card was still introduced prior to beginning the task in order to provide a context for the question-and-answer session.

[3] This data set is comparable in size to prior work on Spanish vowels, such as Quilis & Esgueva (1983), also described in Quilis (1988:174-175), which was based on 660 vowels from 30 productions of the five Spanish vowels in both tonic and atonic positions as produced by 16 males and 6 females from Spain and Latin America.

[4] The data for the vowel /u/ are based on the production of the word *número*, such that some additional vowel quality affects may be due to the surrounding nasals. Quilis (1993:166) notes the reduction in F1 for vowels appearing between nasals and in word-initial position. Likewise, Recasens & Espinosa (2006) consider vowels to

2.2. Measurement

Measurements for each vowel were taken at the midpoint using *Praat* (Boersma & Weenink 2008). The F1, F2 and F3 were extracted with a script in Hz (Lennes 2003), converted to the Bark scale and then normalized using the procedure described in Guion (2003, a.o.) in order to account for differences in vocal tract length among speakers. That is, for each speaker, a *k*-factor was calculated as a ratio of the average F3 value for /a/ (in Bark) for one specific speaker (S1) divided by the average for each individual speaker (S*i*). The *k*-factors for Lima and Cuzco speakers range from 0.97-1.11 (see Table 1A for normalization values used for each speaker). Then the F1 and F2 values for all vowels for each speaker were multiplied by the *k*-factor for that speaker.

2.3. Speakers

The participants in this study are all male with post-secondary education between 20-39 years of age. Speakers were born and raised in the region in which they were recorded (either Lima or Cuzco respectively). The data are divided into four groups consisting of three speakers each. The first two groups include native Spanish speakers from Lima (LIM_L1) and Cuzco (CUZ_L1). The last two groups, also from Cuzco, include bilinguals who spoke both Quechua and Spanish before starting school (CUZ_BL), and native Quechua speakers who learned Spanish after starting school (CUZ_L2).

2.4. Hypotheses

The following hypotheses are proposed. First, the null hypothesis (H0) is that all four groups will show similar behavior with respect to F1 and F2 measurements. That is, L1 speakers in both Lima and Cuzco will behave similarly. Likewise, bilinguals in the Cuzco BL and L2 groups will behave in a similar manner to the L1 speakers. The next hypothesis (H1) is that Lima and Cuzco groups will differ according the F1 and/or F2, since Lima speakers are considered to be in relatively less contact with Quechua than Cuzco speakers. A second hypothesis (H2) is that Cuzco groups will behave differently from the Cuzco L1 group if speakers have knowledge of Quechua (BL and L2 groups). This prediction is based on the expectation that the Quechua 3-vowel phonemic inventory will affect the acquisition of the target Spanish 5-vowel system at least to some degree. Last, if differences are observed, the third hypothesis (H3) predicts that native bilinguals BL will show a behavior that is more similar to Spanish L1 speakers while the L2 group will show a more distinct behavior from the L1 group.

3. Results

In this section, a series of graphs demonstrate the overall shape of the vowel space for each speaker. The un-normalized and normalized mean vowel quality for each speaker can be found in the Appendix, Tables 2A and 3A in order to allow for comparisons with other studies of Spanish vowels, such as those summarized in Willis (2008). First, individual data points were graphed for representative speakers from Lima and Cuzco using a *Praat* script (Lennes 2002), as appears in Figures 1 and 2. Next, the normalized Bark values were graphed according to group, as seen in Figure 3 a)-d). A composite view of the average for all four groups is given in Figure 4 (Lennes 2004) and Figure 5. In the following section, statistical analysis of differences between vowels is given.

In Figures 1 and 2 we can already observe some regional differences in vowel quality between two native Spanish speakers from Lima and Cuzco respectively. In particular, the vowel /i/ appears higher and more front in Figure 2 than in Figure 1. Comparisons between groups in Figure 3 show a generally smaller vowel space for the Lima speakers in Figure 3a) compared to the Cuzco speakers,

---

be most affected by adjacent consonants that are 'antagonistic' to the corresponding vowel. In the case of back vowels, dentoalveolars and labials create a smaller front cavity, which cause the F2 to be raised. However, since all speakers read the same set of utterances, there is internal consistency within this study allowing for a cross-comparison of behavior between groups and speakers. Future research should include examining the affects of stress and surrounding consonants on vowel quality.

most notably for Cuzco L2 speakers shown in Figure 3d). Also, the Cuzco bilingual group in Figure 3c) shows more variability amongst speakers: some speakers (CUZ1_BL, CUZ3_BL) show a vowel space pattern similar to monolinguals in Figure 3b) while the remaining speaker (CUZ2_BL) is more similar to second language speakers in Figure 3d). In Figures 4 and 5 we see that the three Cuzco groups show more fronted vowels for /i/ /e/ and /a/, with higher F2 values. The F1 height difference between /i/ and /a/ is also greater for CUZ_L1 and CUZ_L2 groups, while the CUZ_BL group appears to have an F1 height similar to the LIM_L1 group. The back vowel /o/ appears to be similar in F2 backness for all four groups, although the F1 is higher for the Lima group. The /u/ vowel, on the other hand, appears to be fairly similar in F1 height, but differs according to F2 backness, with Cuz_L1 and Cuz_BL groups being farther forward.

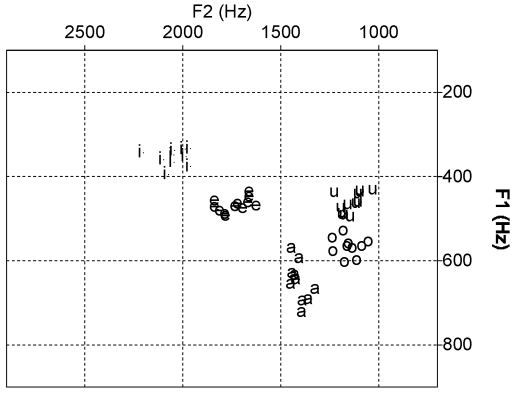

Figure 1. Lima L1 Spanish, in Hz (LIM3_L1). Each vowel represents one data point.

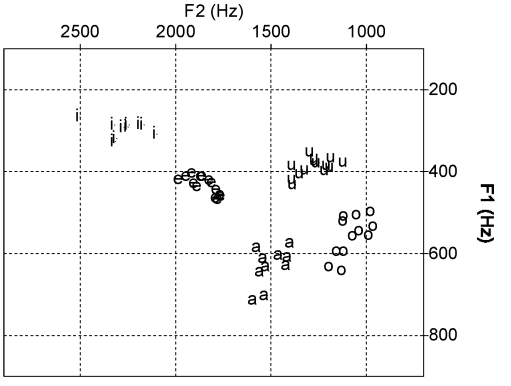

Figure 2. Cuzco L1 Spanish, in Hz (CUZ3_L1). Each vowel represents one data point.

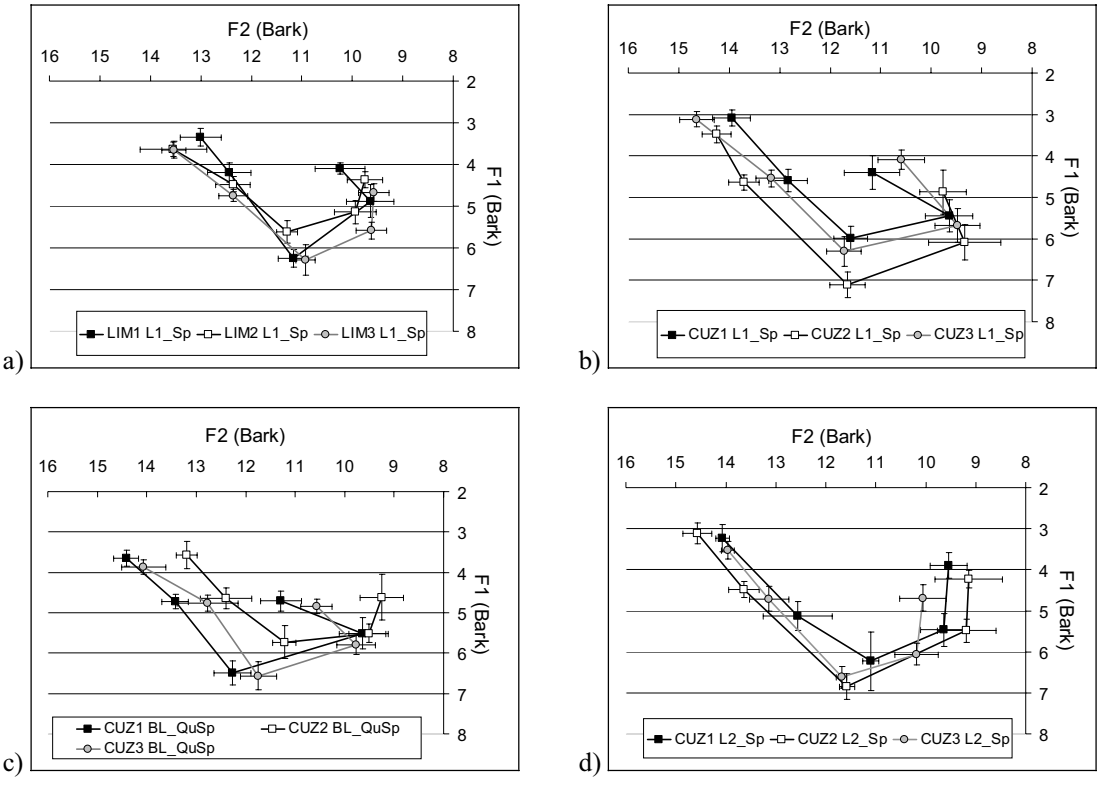

Figure 3. a) Lima L1 group, b) Cuzco L1 group, c) Cuzco bilingual BL group, d) Cuzco L2 group. Data points indicate the mean for each speaker; error bars show one standard deviation.

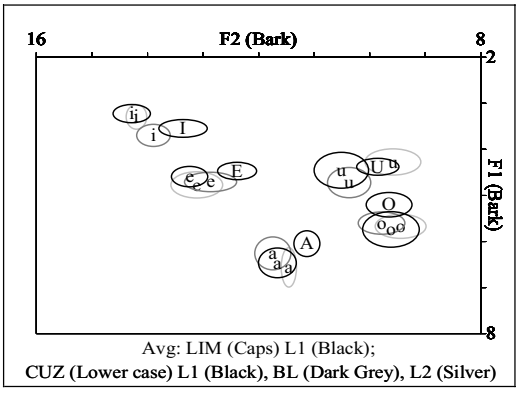

Figure 4. Composite of each group. Vowel indicates mean for each group; ellipse shows one standard deviation.

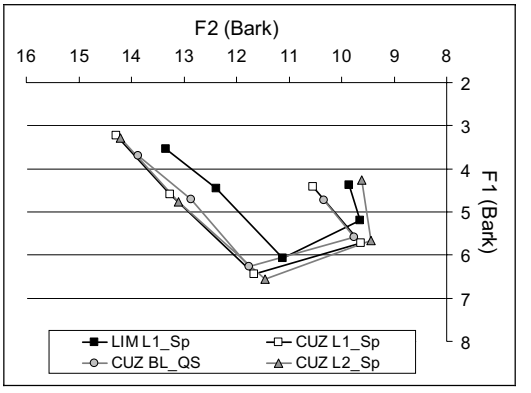

Figure 5. Composite of each group. Data points indicate the mean for each group.

4. Analysis and discussion

In this section, statistical analyses are conducted in order to observe any significant differences in vowel quality in Peruvian Spanish. The first comparison is made within each group according to vowels. A one-way ANOVA analysis for the four groups was conducted with F1 and F2 each as dependent variables, and vowel quality as the independent variable (see Tables 4A and 5A of the Appendix). Significant differences were found between all vowels in either the F1 (height) or F2 (backness) dimensions. Nearly all speakers show a five-way distinction between vowels according to both F1 and F2. However, the F1 height of /e/ and /u/ is not significantly different for all Lima L1 speakers, and nearly all Cuzco speakers (except for CUZ3_L1 and CUZ1_L2 speakers). In addition, the F2 backness of /o/ and /u/ was not significantly different for several speakers, including at least one speaker from each of the Lima and Cuzco groups. From this data, we can see that the back /u/ vowel generally is not higher than the front mid-vowel /e/. Also, the amount of F2 backness is not a distinctive feature for the back vowels /o/ and /u/ for several speakers. In those cases, only height is used to distinguish between the two vowels.

Next, comparisons were made between groups. Figures 6 and 7 show the mean F1 and F2 values for Lima and Cuzco groups. A one-way ANOVA analysis was conducted for each vowel with F1 and F2 each as the dependent variable with group as the independent variable. The results of the post-hoc Tukey-Kramer test are shown in Tables 1 and 2. In part A of each table, Lima L1 speakers are compared to the other three Cuzco groups; in part B, Cuzco L1 speakers are compared to the other two Cuzco groups; in part C, Cuzco native bilinguals are compared to Cuzco L2 speakers.

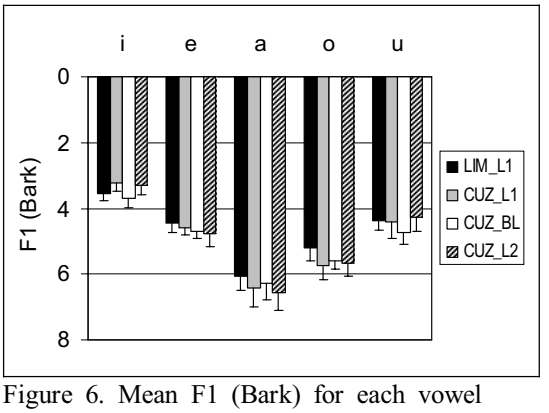

Figure 6. Mean F1 (Bark) for each vowel according to group. Error bars indicate one standard deviation.

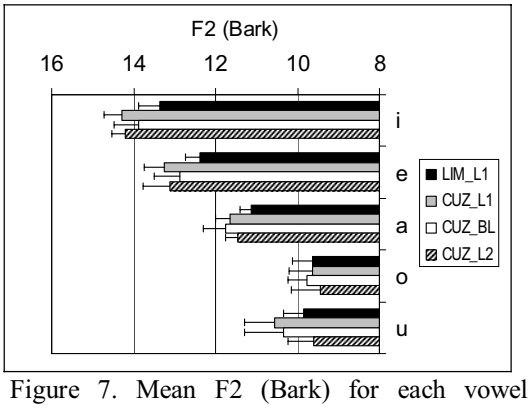

Figure 7. Mean F2 (Bark) for each vowel according to group. Error bars indicate one standard deviation.

F1					
A: LIM L1	/i/	/e/	/a/	/o/	/u/
- CUZ L1	*		*	*	
- CUZ BL		*		*	*
- CUZ L2	*	*	*	*	
B: CUZ L1	/i/	/e/	/a/	/o/	/u/
- CUZ BL	*				*
- CUZ L2		*			
C: CUZ BL	/i/	/e/	/a/	/o/	/u/
- CUZ L2	*				*

Table 1. Results of post-hoc Tukey-Kramer test of F1 vowel quality according to group.

F2					
A: LIM L1	/i/	/e/	/a/	/o/	/u/
- CUZ L1	*	*	*		*
- CUZ BL	*	*	*		*
- CUZ L2	*	*	*		
B: CUZ L1	/i/	/e/	/a/	/o/	/u/
- CUZ BL	*	*		*	
- CUZ L2				*	*
C: CUZ BL	/i/	/e/	/a/	/o/	/u/
- CUZ L2	*		*	*	*

Table 2. Results of post-hoc Tukey-Kramer test of F2 vowel quality according to group.

Note: The asterisk * in Tables 1 and 2 indicates significance at the 0.05 level or below. Part A of each table shows paired comparisons between Lima and three Cuzco groups; part B shows comparisons between three Cuzco groups; part C shows comparisons between Cuzco groups with knowledge of Quechua (bilinguals and L2 speakers).

To summarize these findings in terms of F1 height, in part A of Table 1 the vowels of the Lima L1 group tend to be significantly higher than those of the Cuzco L2 group, except for the vowel /u/. Likewise, the Cuzco L1 group shows no significant differences in height from the Lima group with regard to /u/ and also /e/. The Cuzco bilingual group, on the other hand shows significant height differences precisely for these two vowels /u/ and /e/ as well as /o/. In parts B and C, we see significant differences in height between the Cuzco groups for vowels /i/ and /u/, with the BL group showing lower vowels than the L1 and L2 groups. With the exception of /e/ between Cuzco L1 and L2 groups, no other significant differences in height were observed.

In terms of F2 backness, in part A of Table 2 significant differences were found between Lima L1 speakers and all three Cuzco groups for non-back vowels /i/ /e/ /a/, with Cuzco vowels being significantly farther forward. The vowel /u/ for Cuzco L1 and BL groups was also significantly farther forward than the Lima L1 group. In parts B and C, we see that the bilingual group is significantly different from both the Cuzco L1 group with respect to three vowels /i/ /e/ /o/, but also significantly different from the Cuzco L2 group with respect to four vowels /i/ /a/ /o/ /u/. That is, the bilingual group is behaving differently from both groups with respect to two vowels (/i/and /o/) or rather, the bilingual group is behaving like the L1 group according to /a/ and /u/ but like the L2 group according to /e/. As seen in part B, L2 speakers are most distinct from L1 speakers with respect to the back vowels /o/ and /u/ which are significantly farther back for the L2 group than for the other two Cuzco groups.

Thus, while the speakers in these groups show behavior similar to other Spanish speakers in employing a five-vowel system, there are regional differences observed between coastal speakers in Lima and highland speakers in Cuzco. In addition, within Cuzco the three groups show some differences, most notably between back vowels. Also the bilinguals do not seem to demonstrate as much of a fronted vowel system compared to the other Cuzco speakers.

With respect to the Peruvian Spanish vowel system itself, these speakers show back vowels /o/ and /u/ which are much lower in height than other dialects of Spanish: the vowel /o/ is distinct from the /a/ in terms of backness, and the /u/ is distinct from the /o/ with respect to height. The /u/ is not farther back than the /o/ as has been observed for other Spanish dialects, and in some cases may be even farther forward. This fronting of the /u/ may itself demonstrate that the necessary component of distinction between /a/, /o/ and /u/ is height and not backness. However, as previously noted, other segmental affects on vowel quality may need to be further investigated also.

5. Summary

In this study, we have examined the acoustic quality of vowels in Peruvian Spanish according to the formant values for F1 and F2. Comparisons were made between Lima native Spanish speakers and Cuzco speakers ranging from native Spanish speakers to Quechua-Spanish bilinguals to L2 Spanish speakers. In response to the research questions and hypotheses, regional differences were found, with Cuzco speakers generally showing a larger and more fronted vowel space than Lima speakers. These findings support the claim by Bradlow (1995) that languages may differ according to a 'base-of-articulation' such that the "boundaries of the acoustic vowel space are more accurately defined on a language-specific basis" (1995:1922). In this data set, dialects within the same language also appear to demonstrate a different 'base-of-articulation' even when both dialects possess the same phonemic vowel inventory. Next, within Cuzco the three groups did behave differently according to knowledge of Quechua. As seen in Figure 5, the L2 group showed a larger overall vowel space, while the BL group showed a somewhat smaller space. In terms of how the vowels were organized, both bilinguals and monolinguals demonstrated mid vowels that were slightly closer to the neighboring high vowels rather than being equidistant between the high vowels and the vowel /a/. However, this proximity does not result in overlap of the mid and high vowel qualities (see Figure 4). Related to 'base-of-articulation,' the L2 Spanish speakers showed the greatest amount of backness in /o/ and /u/ vowels (particularly /u/). The bilingual speakers, on the other hand, showed front vowels /i/ and /e/ that were farther back than the other two Cuzco groups.

Returning to the term 'motosidad,' these data show one area in which regional differences may appear to divide the vowel space in such a way that could potentially cause a misinterpretation of the input. Specifically, the high vowel /i/ in Lima demonstrates the same degree of frontness as the mid vowel /e/ for the Cuzco L1 and L2 groups. That is, a Cuzco speaker producing an /e/ may be perceived as producing an /i/ by a Lima listener who is expecting F2 values in that range to correspond to an /i/. Guion (2003:124) notes that "contact-induced change is brought about by the transmission of bilingual reorganized phonetic systems." The present data set suggests that this type of reorganization may contribute to the development of regional differences between Lima and Cuzco. Last, Willis (2005:118) argues for further research on Spanish vowels in order to determine the "impact of language contact and bilingualism." As shown in this study on Peruvian Spanish vowels, bilinguals may behave differently according to whether they are early or late learners. However, it was actually the L2 learners who patterned more similarly to the L1 speakers (especially with respect to the front vowels), while the native bilinguals demonstrated behaviors that were more heterogeneous than the other two groups. Further research related to the production and perception of vowels within Peru is needed to demonstrate to what extent bilingualism and contact with Quechua contribute to the development of dialectal differences observed in Peruvian Spanish vowels.

6. Appendix

Speakers	/a/ Avg F3 in Bark	*k*	Speakers	/a/ Avg F3 in Bark	*k*
LIM1 L1	15.14	1.00	CUZ1 BL	13.73	1.10
LIM2 L1	14.49	1.04	CUZ2 BL	15.06	1.01
LIM3 L1	14.78	1.02	CUZ3 BL	13.72	1.10
CUZ1 L1	14.45	1.05	CUZ1 L2	15.65	0.97
CUZ2 L1	13.61	1.11	CUZ2 L2	14.99	1.01
CUZ3 L1	14.36	1.05	CUZ3 L2	14.83	1.02

Table 1A. *k*-normalization (Guion 2003), where $ki = \frac{\text{Avg F3 (in Bark) of /a/ for S1 (LIM1 L1)}}{\text{Avg F3 (in Bark) of /a/ for Si}}$

Avg Hz		F1	Stdev	F2	Stdev	Avg Hz		F1	Stdev	F2	Stdev
LIM1 L1	/i/	332	21	2001	121	CUZ1 L1	/i/	292	18	2097	113
	/e/	419	25	1839	114		/e/	440	29	1788	96
	/a/	663	28	1519	70		/a/	595	33	1496	72
	/o/	496	36	1153	92		/o/	533	36	1186	67
	/u/	409	14	1319	100		/u/	421	42	1408	110
LIM2 L1	/i/	345	18	1981	186	CUZ2 L1	/i/	309	18	1940	76
	/e/	426	18	1675	85		/e/	417	17	1806	74
	/a/	552	33	1435	46		/a/	682	37	1367	66
	/o/	503	31	1175	78		/o/	565	47	981	105
	/u/	419	20	1146	62		/u/	440	52	1044	71
LIM3 L1	/i/	354	21	2060	77	CUZ3 L1	/i/	293	18	2284	113
	/e/	468	17	1729	69		/e/	431	22	1849	74
	/a/	651	48	1402	41		/a/	629	45	1508	73
	/o/	563	25	1160	53		/o/	556	47	1082	74
	/u/	462	23	1147	54		/u/	386	23	1280	87

Avg Hz		F1	Stdev	F2	Stdev	Avg Hz		F1	Stdev	F2	Stdev
CUZ1 BL	/i/	328	18	2020	71	CUZ1 L2	/i/	331	35	2518	54
	/e/	428	17	1765	65		/e/	545	44	2002	206
	/a/	617	34	1509	79		/a/	692	100	1589	40
	/o/	509	28	1107	74		/o/	588	29	1129	66
	/u/	428	24	1317	77		/u/	402	35	1242	75
CUZ2 BL	/i/	352	34	2034	62	CUZ2 L2	/i/	306	24	2472	106
	/e/	466	29	1811	133		/e/	445	21	2153	95
	/a/	593	51	1515	54		/a/	735	42	1586	36
	/o/	566	27	1165	73		/o/	561	34	1100	105
	/u/	464	63	1118	79		/u/	418	24	1093	119
CUZ3 BL	/i/	347	17	1924	114	CUZ3 L2	/i/	343	22	2208	42
	/e/	432	20	1617	136		/e/	466	33	1960	112
	/a/	624	42	1401	72		/a/	695	34	1583	23
	/o/	538	26	1056	61		/o/	623	34	1265	83
	/u/	440	18	1187	53		/u/	464	34	1242	91

Table 2A. Average F1 and F2 values (in Hz) of five vowels for each speaker with standard deviation

Avg Bark, Normalized		F1	Stdev	F2	Stdev	Avg Bark, Normalized		F1	Stdev	F2	Stdev
LIM1 L1	/i/	3.35	0.20	13.00	0.41	CUZ1 L1	/i/	3.09	0.20	13.95	0.38
	/e/	4.19	0.23	12.44	0.43		/e/	4.59	0.27	12.84	0.38
	/a/	6.24	0.21	11.17	0.30		/a/	5.98	0.28	11.60	0.33
	/o/	4.88	0.40	9.64	0.47		/o/	5.45	0.40	9.64	0.47
	/u/	4.10	0.14	10.24	0.49		/u/	4.40	0.41	11.17	0.55
LIM2 L1	/i/	3.64	0.18	13.54	0.66	CUZ2 L1	/i/	3.47	0.21	14.25	0.29
	/e/	4.47	0.19	12.36	0.34		/e/	4.64	0.18	13.71	0.31
	/a/	5.61	0.27	11.29	0.21		/a/	7.11	0.32	11.66	0.35
	/o/	5.14	0.27	9.94	0.42		/o/	6.08	0.43	9.34	0.72
	/u/	4.36	0.19	9.75	0.35		/u/	4.87	0.53	9.77	0.46
LIM3 L1	/i/	3.65	0.20	13.53	0.24	CUZ3 L1	/i/	3.12	0.19	14.65	0.34
	/e/	4.74	0.15	12.36	0.29		/e/	4.54	0.21	13.18	0.29
	/a/	6.29	0.36	10.92	0.19		/a/	6.31	0.37	11.72	0.34
	/o/	5.58	0.20	9.62	0.31		/o/	5.68	0.41	9.48	0.44
	/u/	4.68	0.22	9.57	0.30		/u/	4.09	0.23	10.60	0.46

Avg Bark, Normalized		F1	Stdev	F2	Stdev	Avg Bark, Normalized		F1	Stdev	F2	Stdev
CUZ1 BL	/i/	3.66	0.20	14.42	0.26	CUZ1 L2	/i/	3.23	0.34	14.07	0.14
	/e/	4.71	0.18	13.42	0.27		/e/	5.12	0.36	12.56	0.70
	/a/	6.49	0.30	12.27	0.38		/a/	6.23	0.71	11.10	0.16
	/o/	5.51	0.40	9.64	0.47		/o/	5.47	0.23	8.96	0.36
	/u/	4.71	0.24	11.29	0.41		/u/	3.90	0.31	9.54	0.37
CUZ2 BL	/i/	3.57	0.34	13.20	0.21	CUZ2 L2	/i/	3.12	0.25	14.57	0.29
	/e/	4.65	0.26	12.40	0.51		/e/	4.48	0.20	13.64	0.30
	/a/	5.73	0.42	11.22	0.23		/a/	6.85	0.31	11.58	0.15
	/o/	5.51	0.22	9.51	0.40		/o/	5.49	0.29	9.19	0.58
	/u/	4.62	0.57	9.25	0.44		/u/	4.23	0.22	9.14	0.68
CUZ3 BL	/i/	3.86	0.18	14.06	0.44	CUZ3 L2	/i/	3.53	0.22	13.96	0.13
	/e/	4.76	0.20	12.77	0.62		/e/	4.71	0.30	13.13	0.40
	/a/	6.56	0.36	11.74	0.37		/a/	6.62	0.26	11.69	0.10
	/o/	5.79	0.24	9.77	0.39		/o/	6.06	0.27	10.18	0.43
	/u/	4.84	0.18	10.57	0.31		/u/	4.69	0.32	10.06	0.47

Table 3A. Average F1 and F2 values (in Bark, normalized) of five vowels for each speaker with standard deviation.

Speaker	F1	/a/, /e/	/a/, /i/	/a/, /o/	/a/, /u/	/e/, /i/	/e/, /o/	/e/, /u/	/i/, /o/	/i/, /u/	/o/, /u/
LIM1_L1	F(4,55)=240.5	*	*	*	*	*	*	nsd	*	*	*
LIM2_L1	F(4,49)=110.9	*	*	*	*	*	*	nsd	*	*	*
LIM3_L1	F(4,50)=184.7	*	*	*	*	*	*	nsd	*	*	*
CUZ1_L1	F(4,56)=140.1	*	*	*	*	*	*	nsd	*	*	*
CUZ2_L1	F(4,53)=168.5	*	*	*	*	*	*	nsd	*	*	*
CUZ3_L1	F(4,55)=201.8	*	*	*	*	*	*	*	*	*	*
CUZ1_BL	F(4,51)=195.4	*	*	*	*	*	*	nsd	*	*	*
CUZ2_BL	F(4,55)=53.3	*	*	Nsd	*	*	*	nsd	*	*	*
CUZ3_BL	F(4,51)=197.4	*	*	*	*	*	*	nsd	*	*	*
CUZ1_L2	F(4,55)=95.4	*	*	*	*	*	nsd	*	*	*	*
CUZ2_L2	F(4,51)=314.0	*	*	*	*	*	*	nsd	*	*	*
CUZ3_L2	F(4,53)=190.9	*	*	*	*	*	*	nsd	*	*	*

Table 4A. Results from ANOVA analysis and post-hoc Tukey-Kramer test of vowel quality per speaker according to F1. The asterisk * indicates significance at the 0.05 level or below; nsd=no significant difference.

Speaker	F2	/a/, /e/	/a/, /i/	/a/, /o/	/a/, /u/	/e/, /i/	/e/, /o/	/e/, /u/	/i/, /o/	/i/, /u/	/o/, /u/
LIM1_L1	F(4,55)=136.3	*	*	*	*	*	*	*	*	*	*
LIM2_L1	F(4,49)=164.0	*	*	*	*	*	*	*	*	*	nsd
LIM3_L1	F(4,50)=444.2	*	*	*	*	*	*	*	*	*	nsd
CUZ1_L1	F(4,56)=154.5	*	*	*	nsd	*	*	*	*	*	*
CUZ2_L1	F(4,53)=291.0	*	*	*	*	*	*	*	*	*	nsd
CUZ3_L1	F(4,55)=322.7	*	*	*	*	*	*	*	*	*	*
CUZ1_BL	F(4,51)=223.5	*	*	*	*	*	*	*	*	*	*
CUZ2_BL	F(4,55)=238.6	*	*	*	*	*	*	*	*	*	nsd
CUZ3_BL	F(4,51)=163.3	*	*	*	*	*	*	*	*	*	*
CUZ1_L2	F(4,55)=288.5	*	*	*	*	*	*	*	*	*	*
CUZ2_L2	F(4,51)=350.5	*	*	*	*	*	*	*	*	*	nsd
CUZ3_L2	F(4,53)=262.9	*	*	*	*	*	*	*	*	*	nsd

Table 5A. Results from ANOVA analysis and post-hoc Tukey-Kramer test of vowel quality per speaker according to F2. The asterisk * indicates significance at the 0.05 level or below; nsd=no significant difference.

References

Baker, Wendy & Pavel Trofimovich. (2005). Interaction of native- and second-language vowel system(s) in early and late bilinguals. *Language and Speech* 48(1): 1-27.

Boersma, Paul & David Weenink. (2006). *Praat: Doing phonetics by computer* (version 4.4.24) http://www.praat.org/ (20 June 2006).

Bradlow, Ann R. (1995). A comparative acoustic study of English and Spanish vowels. *Journal of the Acoustic Society of America* 97(3): 1916-1924.

Cerrón-Palomino, Rodolfo. (1994). *Quechumara: Estructuras paralelas de las lenguas quechua y aimara* Vol. 42: Cuadros de investigación. La Paz, Bolivia: Centro de Investigación y Promoción del Campesinado.

Chen, Yudong. (2007). *A comparison of Spanish produced by Chinese L2 learners and native speakers: An acoustic phonetics approach.* Ph.D. Dissertation, University of Illinois at Urbana-Champaign.

Delforge, Ann Marie. (2008). Unstressed vowel reduction in Andean Spanish. *Selected Proceedings of the 3rd Conference on Laboratory Approaches to Spanish Phonology*, ed. by Laura Colantoni & Jeffrey Steele, 108-124. Somerville, MA: Cascadilla Proceedings

Escobar, Alberto. (1978). *Variaciones sociolingüísticas del castellano en el Perú*. Lima: Instituto de Estudios Peruanos.

Flege, James Emil, Ocke-Schwen Bohn & Sunyoung Jang. (1997). Effects of experience on non-native speakers' production and perception of English vowels. *Journal of Phonetics* 25: 437-470.

Garrido, Marisol. (2007). Diphthongization of mid/low vowel sequences in Colombian Spanish. In *Selected Proceedings of the Third Workshop on Spanish Sociolinguistics*, ed. by Jonathan Holmquist et al., 30-37. Somerville, MA: Cascadilla Proceedings Project.

Guion, Susan G. (2003). The vowel systems of Quichua-Spanish bilinguals. *Phonetica* 60:98-128.

Lennes, Mietta. (2003). Collect_formant_data_from_files.praat. http://www.helsinki.fi/~lennes/praat-scripts/ (28 October 2007).

Lennes, Mietta. (2002). Draw_formant_chart.praat. http://www.helsinki.fi/~lennes/praat-scripts/ (13 March 2008).

Lennes, Mietta. (2004). Draw_formant_point_to_Bark_chart.praat. http://www.helsinki.fi/~lennes/praat-scripts/ (4 September 2008).

Lipski, John M. (1994). *Latin American Spanish*. London & New York: Longman.

Morrison, Geoffrey Stewart, & Escudero, Paola. (2007). A cross-dialect comparison of Peninsular- and Peruvian-Spanish vowels. In *Proceedings from the XVI International Congress of Phonetic Sciences*, Saarbrücken, Germany. August 6-10, 2007. 1505-1508.

Oliver Rajan, Julia. (2007). Mobility and its effects on vowel raising in the coffee zone of Puerto Rico. In *Selected Proceedings of the Third Workshop on Spanish Sociolinguistics*, ed. by Jonathan Holmquist et al., 44-52. Somerville, MA: Cascadilla Proceedings Project.

Quilis, Antonio. (1988). *Fonética acústica de la lengua española*. Madrid: Gredos.

Quilis, Antonio. (1993). *Tratado de fonología y fonética españolas*. Madrid: Gredos.

Quilis, Antonio & Manuel Esgueva. (1983). Realización de los fonemas vocálicos españoles en posición fonética normal. In *Estudios de fonética*, ed. by Manuel Esgueva & Margarita Cantarero, 159-251. Madrid: Consejo Superior de Investigaciones Científicas.

Recasens, Daniel & Aina Espinosa. (2006). Dispersion and variability of Catalan vowels. *Speech Communication* 48: 645-666.

Rivarola, José Luis. (2000). *Español andino: Textos bilingües de los siglos XVI y XVII.* Madrid: Iberoamericana; Frankfurt am Main: Vervuert.

Willis, Erik W. (2005). An initial estimation of Southwest Spanish vowels. *Southwest Journal of Linguistics* 24(1&2):185-198.

Willis, Erik W. (2008). No se comen, pero sí se mascan: Variación de las vocales plenas en la República Dominicana. *Actas del XV Congreso Internacional de la Asociación de Lingüística y Filología de América Latina (ALFAL)*. Montevideo, Uruguay, August 18-21, 2008. 6pp.

Selected Proceedings of the 4th Conference on Laboratory Approaches to Spanish Phonology

edited by Marta Ortega-Llebaria

Cascadilla Proceedings Project Somerville, MA 2010

ISBN 978-1-57473-438-6 library binding

Ordering information

Orders for the library binding edition are handled by Cascadilla Press.
To place an order, go to www.lingref.com or contact:

Cascadilla Press, P.O. Box 440355, Somerville, MA 02144, USA
phone: 1-617-776-2370, fax: 1-617-776-2271, e-mail: sales@cascadilla.com

Web access and citation information

This entire proceedings can also be viewed on the web at www.lingref.com. Each paper has a unique document # which can be added to citations to facilitate access. The document # should not replace the full citation.

This paper can be cited as:

O'Rourke, Erin. 2010. Dialect Differences and the Bilingual Vowel Space in Peruvian Spanish. In *Selected Proceedings of the 4th Conference on Laboratory Approaches to Spanish Phonology*, ed. Marta Ortega-Llebaria, 20-30. Somerville, MA: Cascadilla Proceedings Project. www.lingref.com, document #2363.