Production of English Front Vowels by Brazilian EFL Teachers in Western Rio Grande do Norte

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1. Introduction

Studies involving vowel production and perception have been carried out for quite a long time. The most quoted research of this kind seems to be the one developed by Peterson & Barney (1952), which is more than half a century old. More recent studies on English as a second or foreign language, however, are also very common owing to the importance attached to the English language as the *lingua franca* of the information world.

These studies frequently focus on the production of English as a second language (Baker & Trofimovich, 2005; Flege, Schirru, & MacKay, 2003; Cebrian, 2006), on perception only (Højen & Flege, 2006; Flege & MacKay, 2005), or on both skills (Jia, Strange, Collado, Wu & Guan, 2006).

Since the present study is mainly aimed at the discussion of production models of English front vowels as produced by Brazilian learners, we focus our attention on the results presented by Baptista (2000), Rauber, Escudero, Bion and Baptista (2005), Bion, Escudero, Rauber and Baptista (2006), and Rauber (2006).

Acoustic studies involving English front vowels by Brazilian learners seem to have begun with the study carried out by Baptista (2000). This study is based on her Ph.D. dissertation written in the early 1990s. The study focuses on the L2 sounds [i, ɪ, eɪ, ɛ, æ, ɑ, ʌ] as compared to their L1 counterparts in a similar context. Only the first sound of the diphthong is analyzed. The phonotactic environment was CVC words in English and CVCV words ending in [ta] in Portuguese. The carrier sentences "Say X now" and "Fala X de novo" are used to provide a stable prosodic environment. Baptista (2000) analyzed her informers' productions of the aforementioned vowels in a longitudinal research project whose main aim was to characterize the acquisition of L2 vowels by Brazilians in the United States.

Her results indicate a holistic approach to vowel acquisition. For instance, in acquiring [ɪ] some informers lowered their production of the first sound of the diphthong [eɪ]. Another interesting conclusion reveals the necessity of rearranging the L2 vowel space not only near new vowels, but also in the system periphery. This is very important when we take into consideration the front vowel system of English has more sounds than the Portuguese one.

Later developments in the acquisition/description of the acoustic properties of Brazilian Portuguese and English interphonology are directly related to Professor Baptista as we will observe.

Inside a newer paradigm of interlanguage (IL) studies determining both production and perception, Rauber, Escudero, Bion, & Baptista (2005) studied both skills regarding English vowels as realized by advanced learners in Brazil.

Two experiments were designed on the basis of this two-fold objective. The first one was a production experiment in which words following a CVC pattern for English and CVCV pattern for Portuguese were used. Both word sets were realized in sentence final position. The second one was a perception experiment in which bVt words were inserted in the context explained above and read by native American English speakers from different American states. The perception task consisted in the identification of the different vowels in a small sequence of sentences.

Perception results indicated a good level of accuracy regarding the high-front pair [i, ɪ], which achieved a score as high as 94%. The low-front pair [ɛ, æ], on the other hand, is poorly distinguished with results achieving only 44% of correct recognition by the informers. Results involving production largely reflect this trend. The pair [i, ɪ] is produced in a rather distinct manner while the pair [ɛ, æ] is poorly discriminated in production as well.

Another study involving the same authors and the same subject matter (Bion, Escudero, Rauber, & Baptista, 2006) aimed at relating perception of the pairs [i, ɪ] as well as [ɛ, æ] to their production.

Three experiments were designed for the purposes of this study. In the first one, Brazilian informers produced L2 vowel sounds in a CVC frame where one of the sounds [p, b, f, s, k, g, h] was in onset position and [t] in coda position. Different carrier sentences were used to elicit the words intended. In the second experiment, Brazilian learners categorized bVt words as realized by native American English speakers of different origins. Finally, in the third experiment, they discriminated a synthesized vowel in a continuum from one component of each pair to the other. In this last step of the study, both vowels of each pair had equal duration in order to allow experimenters to determine the value of duration in the perception of non-native speakers of English.

As expected, the results of the production experiment indicate the majority of the speakers of English as a foreign language realize smaller differences between the constituents than natives do. The pair [ɛ, æ] is more difficult to produce than the pair [i, ɪ] as indicated by Bion *et al.* (2006) in a previous research. As regards perception of natural speech, Brazilian learners achieved near-native perception of the pair [i, ɪ]. The pair [ɛ, æ] is once again not well discriminated.

An analysis of the results of the last perception experiment, involving synthesized vowels, again shows the difficulty in achieving a good level of discrimination between the constituents of the pair [ɛ, æ].

The most recent research is a Ph.D. dissertation. Rauber (2006), advised by Professor Baptista, studied the vowels of Brazilian advanced users of English as a foreign language. She studied almost all L2 vowels, but we will here limit our discussion to the front vowels regarding the scope of our discussion.

CVC words were used for data collecting. The consonants in onset and coda positions were voiceless in order to facilitate the analysis of the periodic pulses of the vowels. The carrier sentence was a little cumbersome “X. X and Y sound like Z”. However, this assured a bigger number of vowels analyzed, produced replacing the second X and Y above, with a smaller number of repetitions. Words replacing the first X and Z were not analyzed acoustically.

To study perception aspects, Rauber (2006) used isolated synthesized vowels in a continuum involving different F1 and F2 values and three different durations. The test involved hearing an artificial vowel and then choosing the most similar one of the eleven vowels studied.

Perception tests concluded that informers used duration as their primary cue for distinguishing between the constituents of the pairs [i, ɪ] and [ɛ, æ]. Once again the first pair was distinguished in a near-native fashion, while perception of the second pair did not achieve this level of proficiency.

Concerning vowel articulation, results indicated no formant overlap between the constituents of the pair [i, ɪ]. The same degree of independence was not achieved when we take into consideration the pair [ɛ, æ] which had a great degree of overlap of both F1 and F2 values.

As regards duration, significant differences were found within the pairs. The vowels [ɪ] and [ɛ] were produced significantly shorter than the other constituent of their respective pair.

An important limitation of the aforementioned studies, however, needs to be pointed out: Informers are normally from the southern states of Brazil. Since there is a great sociolinguistic variation in our country, similar studies need to be carried out in different regions in order to validate or not the conclusions above as regards different varieties of Brazilian Portuguese.

The primary aim of this research, thus, is to provide the description of the relationship between our mother language and English as a foreign language as spoken by our teachers who deal with oral skills in the classroom. Both acoustic and duration aspects of the front vowel system of English as a foreign language and our variant of Brazilian Portuguese are described having the establishment of this relationship in mind.

2. Method

Our study group was composed of male teachers of English, between 19 and 56 years of age. All but one had or were having training in English at a university level and had never been abroad before. Though 25 subjects had originally been recorded for this research, only 20 informers were eventually selected owing to problems ranging from bad recording quality to long stays in English speaking countries.

Our data collection procedure consisted of four experiments: two for L1 and two for L2 recordings. In particular, the first data collection procedure in both languages involved the reading of words in carrier sentences. The following procedure was a role-play activity in which informers were required to give instructions on how to get to specific places with the aid of a small map.

L1 first experiment included Brazilian Portuguese front vowels [i, e, eɪ, ɛ] in CVCV words. The first consonant was a voiced or voiceless plosive and the second one a voiceless plosive. Only the first vowels were analyzed acoustically. The words *Tita, deita, beco,* and *beca* were inserted into the carrier sentence *Diga X de novo,* Portuguese translation for *Say X again.* Every sentence was read three times and there was an equal number of distractors. These procedures resulted in 240 vowel tokens to be analyzed. From this point onward, this experiment will be termed L1-1.

The second L1 collection experiment was performed with the aid of the map presented in Figure 1. Informers were presented with a map and asked, for example, to indicate how to get from the hospital (center low) to the club (center high). In order to do so, subjects needed to use the street names presented in the map. These names are the same as the words in our L1-1 experiment. Each word was recorded five times, for we believed we would find more variation in these vowels than in our previous experiment. Only one distractor was used. 400 tokens were, thus, recorded for this second procedure. From this point onward, this experiment will be termed L1-2.

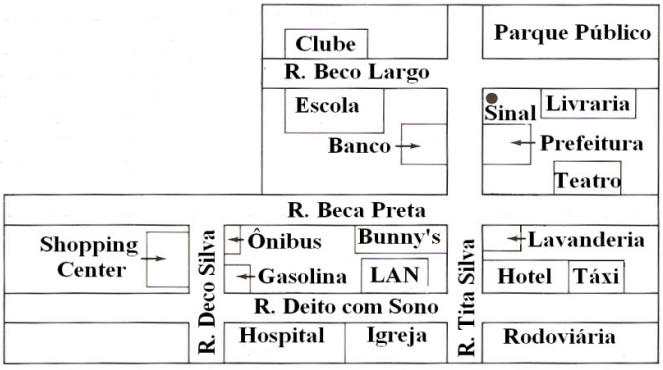

Figure 1. Map for eliciting L1 front vowels

L2 experiments follow the same principles stated above. The first experiment of the L2 (L2-1) contains one of the five vowels [i, ɪ, eɪ, ɛ, æ] in real English words in a CVC context. The consonant in onset position is either a voiced or voiceless plosive. The consonant in coda position is always a voiceless plosive. The words *beat, tip, date, bet,* and *cat* were inserted into a carrier sentence following the model *Say X again*. L2-1 experiment generated 300 vowel tokens to be analyzed.

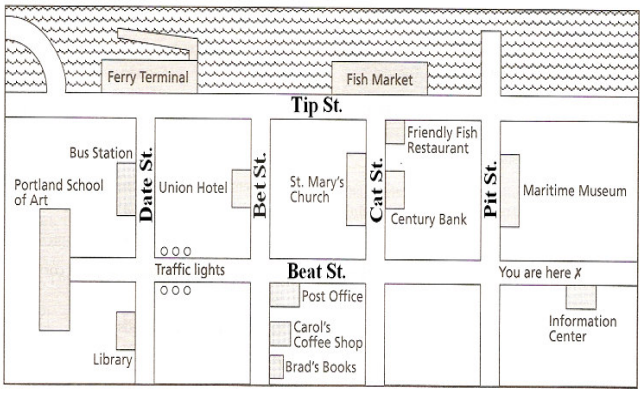

Figure 2. Map for eliciting L2 front vowels

The second data collection experiment in L2 (L2-2) uses Figure 2 as a starting point for eliciting the same words presented above in a role-play activity with identical procedures to those discussed in L1-2. L2-2 experiment, thus, generated 500 vowel tokens to be analyzed. Only one distractor was used.

The overall vowel tokens to be analyzed were, consequently, 1,440. Three measurements were performed for each vowel, thus elevating the number of variables to 4,320. Formant analyses were carried out in the middle of the vowel, except the diphthongs, which only had their first element studied. Duration analyses excluded VOT of the onset consonant and measuring from the first to the last wave pressure peak of the vowel's periodical wave. No duration was measured for the diphthongs. This amount of data was analyzed statistically by using paired-sample t-tests, when dealing with two variables, and repeated measures ANOVAs, when dealing with 3+ variables. Significant values were set to

$p < .05$. Euclidean distance values were also used to determine if vowel system pairs were articulated in a significantly closer or farther way inter-experimentally. All statistical analyses were carried out using the software SPSS.

Acoustic analyses were performed in *Praat*, version 4.6.21. The software was configured to search for only 5 formants on a ceiling of 5000 Hz. Additional configurations were set to include a 50 ms window length and a 25 ms time step. All recordings were carried out in a quiet room with no acoustic treatment.

Recording hardware included a Shure SM-58 unidirectional dynamic microphone with a frequency response ranging from 50 to 15000 Hz. The digital recorder was an M-Audio Microtrack 24/96 recording Wave files in a 16 bit, 44000 Hz configuration.

3. Results

This section will be presented in three parts: *duration* (discussed inter- and intra-experimentally), *L1-1/L2-1 experiments* and *L1-2/L2-2 experiments* comparison of acoustic spectra.

3.1 Duration

All but one L2 vowels were significantly different from L1 ones when compared. This was expected owing to the well known value of duration in characterizing English front vowels, and the absence of this characteristic in the Brazilian Portuguese vowel system.

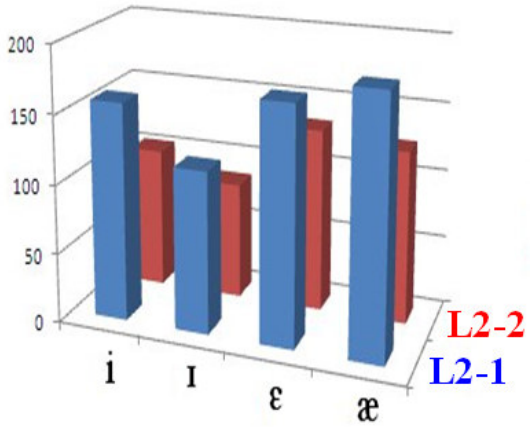

Figure 3: L2 inter-experiment comparison

L2 inter-experiment comparisons involving results of L2-1 and L2-2 indicated all vowels of the former were realized significantly longer than the ones of the latter. This can be visualized in Figure 3.

As regards intra-comparisons, in the high pair [i, ɪ] the first sound is realized with a highly significant level of difference ($p= .000$) in both L2-1 and L2-2 experiments.

The low pair [ɛ, æ], on the other hand, does not show significant difference in both L2-1 ($p= .051$) and L2-2 ($p= .125$). It is noteworthy that results for this pair in the L2-2 experiment even contradict the linguistic principle of lower vowels being longer in duration.

Inter-language comparison showed one highly non-significant difference in duration ($p= .824$) when L1-2 [e] and L2-2 [ɪ] were analyzed. This revealed the first similarity between

these sounds found out in the present study. All results for L2 vowel duration are shown in Table 1.

Table 1. Overall results for L2 vowel duration

	L2-1				L2-2			
	i	ɪ	ɛ	æ	i	ɪ	ɛ	æ
Mean	158	118	171	186	103	85	133	125
Median	151	114	167	187	96	90	123	122
Standard Deviation (SD)	34	29	31	47	29	24	29	31

3.2 L1-1/L2-1 experiments

As expected, all L1 vowels were significantly different from one another. As regards L2 intra-comparison, the high front pair [i, ɪ] is significantly different on both F1 and F2 axes. The first element of the diphthong [eɪ], however, relates to the sound [ɪ] in highness (p= .107), but not in frontness (p= .020). The vowel plot of Figure 4 illustrates these observations.

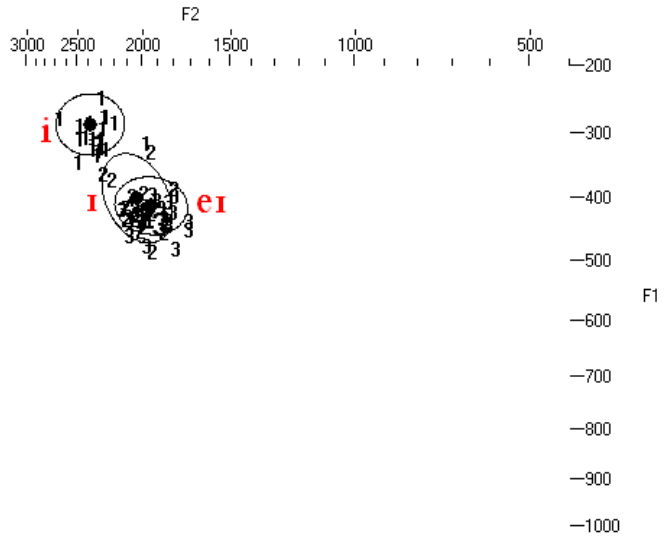

Figure 4. Plot of L2-1 high vowels

When we observe the low pair [ɛ, æ], at first glance, we notice the great degree of overlap shown in Figure 5. Statistical analysis of these vowels, however, indicates a barely significant difference in both F1 (p= .043) and F2 (p= .040). It is noteworthy here that the vowel [æ] has very high values of standard deviation regarding highness (F1) as shown in Table 2.

Inter-comparison of L2-1 and L1-1 experiments showed that L1 [i] has no significant difference from L2 [i] as regards highness (p= .598), but not frontness (p= .000). For L1 [ɛ], it was found this sound was completely different from the low L2 pair [ɛ, æ] concerning highness (both p= .000), but not frontness (p= .566 for [ɛ]; p= .247 for [æ]).

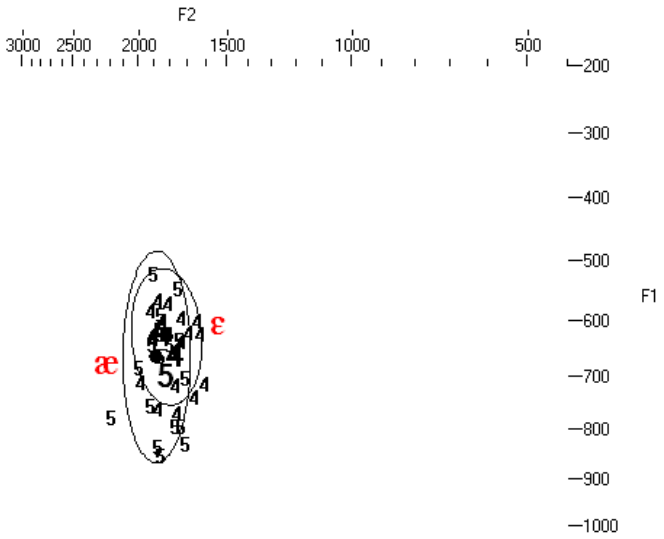

Figure 5. Plot of L2-1 low vowels

L1 [e] is significantly higher than L2 [ɪ] (p= .001), but they share a similar degree of frontness (p= .247). A big degree of overlap can be observed when these two vowels are compared.

In order to analyze if the L2 front vowel system was significantly longer than the L1 one, the Euclidean distance of the L2-1 vowels [i, æ] and L1-1 [i, ɛ] was measured for each informer and these values were then compared. A significant difference was found (p= .005), implying our L2 has a longer front vowel system than our L1.

Table 2. Overall values of L2-1 and L1-1 vowels

	L2-1									
	i		ɪ		eɪ		ɛ		æ	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Mean	288	2389	401	2036	413	1942	630	1823	668	1883
Median	293	2399	409	2037	408	1950	609	1831	635	1887
SD	23	142	35	124	23	121	62	107	97	111
	L1-1									
	i		eɪ		e		ɛ			
	F1	F2	F1	F2	F1	F2	F1	F2		
Mean	292	2284	409	1890	366	2076	550	1860		
Median	289	2312	413	1883	368	2085	546	1843		
SD	25	123	26	80	19	94	47	110		

3.3 L1-2/L2-2 experiments

Intra-comparison of the L2-2 sounds reveals very similar results to the ones presented above. Once again the relation between L1 [e] and L2 [ɪ] was established, with the same level of significance achieved for F1 (p= .001). These vowels still share a considerable degree of overlap as observed in Figure 6. The only relevant difference seems to be the non-significant difference (p= .420) in highness (F1) regarding the low pair [ɛ, æ].

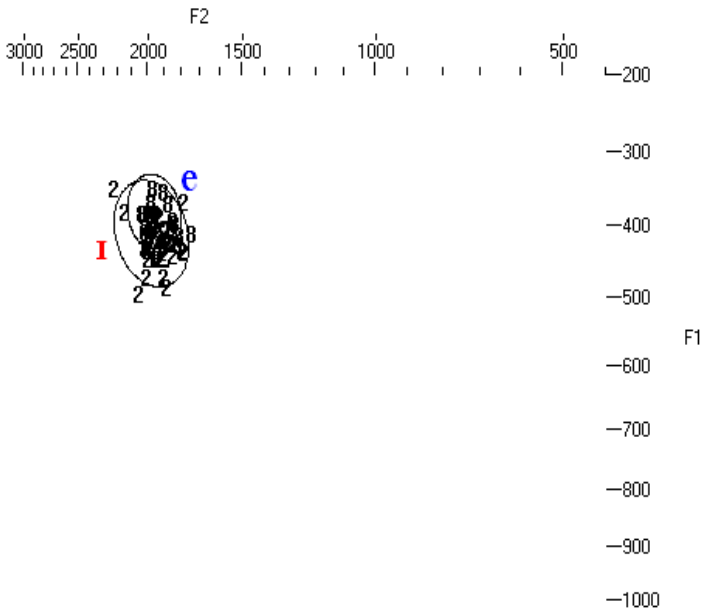

Figure 6. Plot of L1-2/L2-2 vowels

Euclidean distance measurements also indicate the L2 front vowel system is significantly longer (p= .001). Results of the measurements made in L1-2 and L2-2 experiments can be found in Table 3.

Table 3. Overall values of L2-2 and L1-2 vowels

	L2-2									
	i		ɪ		eɪ		ɛ		æ	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Mean	310	2274	411	1976	426	1879	617	1730	625	1786
Median	305	2282	415	1954	433	1883	607	1731	608	1786
SD	26	132	37	120	21	93	50	78	61	85
	L1-2									
	i		eɪ		e		ɛ			
	F1	F2	F1	F2	F1	F2	F1	F2		
Mean	311	2126	396	1860	384	1956	530	1754		
Median	308	2102	393	1846	383	1980	531	1746		
SD	25	123	23	95	27	82	34	74		

4. Conclusions

Data presented above allow us to conclude most of the results presented in previous studies regarding other sociolinguistic variants of Brazilian Portuguese and English as a foreign language apply to western Rio Grande do Norte subjects.

As regards the high-front pair [i, ɪ], our results indicated a good degree of control in both L2-1 and L2-2 experiments. The aforementioned vowels showed no overlap when we took into

consideration acoustic space. Duration was also used accordingly by realizing the first element of the pair [i] in a significantly longer way than the second one [ɪ] in both L2 experiments.

Comparisons between both L2 and L1 experiments indicated these two high front vowels were realized this way owing to the association of these L2 sounds with their L1 counterparts. L2 [i] was produced in a similar way to L1 [i], and so were L2 [ɪ] and L1 [e] respectively. The lack of necessity of creating a new vowel category in this high area of the L2 vowel space may account for the substantial difference found in this pair. It is also memorable the only non-significant difference relating to vowel duration arose when we compared L1-2 [e] and L2-2 [ɪ].

L2 vowel [ɪ] and the first element of the L2 diphthong [eɪ], on the other hand, did not show significant differences, demonstrating a high degree of overlap in their vowel spaces in both L2 experiments.

Shedding some light on the low-front pair [ɛ, æ], correctly predicted to be the most troublesome front sounds for Brazilian speakers of English as a foreign language, our statistical analysis showed [ɛ, æ] were significantly different from L1 [ɛ]. Duration measurements in both L2 experiments, however, indicate the constituents of the pair above did not differ significantly.

Considering intra-experiment vowel space comparisons, the sounds of the pair [ɛ, æ] were significantly different from each other in both F1 and F2 in experiment L2-1, and in F2 only in experiment L2-2. Even though this pair showed statistically significant differences in three out of the four measurements carried out, the great standard deviation of the L2-1 vowel [æ] (see Figure 5 and Table 2 above) may have masked these results. L2-2 comparison of this pair, shown in Figure 7, presented a smaller degree of variation in the F1 axis and no significant difference for this axis was found.

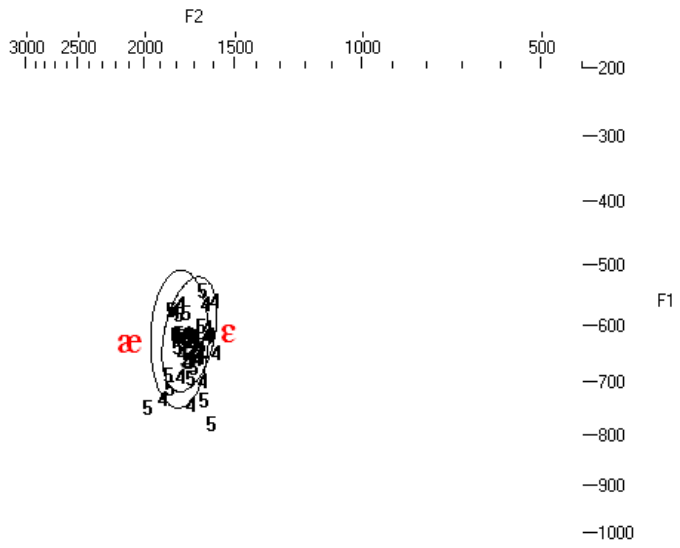

Figure 7. L2-2 low vowels

Bearing in mind these findings, we conclude a single new vowel category for the L2 low-front vowel pair [ɛ, æ] has been created. This new category is significantly lower than L1 vowel [ɛ], which probably explains why our subjects deal inaccurately with both spectral and duration optimal cues for these sounds.

This new L2 vowel category is further corroborated by the significant differences found when comparing the Euclidean distances between the highest and lowest vowel in L1

[i, ɛ] and L2 [i, æ]. Inter-language comparisons indicate L2 vowel systems were always longer than the systems occupied by L1 vowel sounds.

These conclusions are, of course, limited in the sense the present research does not allow us to make broader generalizations. Even though we consider the small number of subjects and vowel tokens a limiting factor, we think it is not so important as the impossibility of making formant movement measurements throughout the vowel. Another limitation is related to the use of written language in the four experiments. In fact, despite the significant variation that was found between the two kinds of experiments, we believe the analysis of free speech would reveal much more than what we were able to find in the present study. Even though we recognize the limitations presented above, they are, in themselves, proposals for future research.

We also consider these problems do not alter the validity of our research since our results seem to corroborate most of the previous studies carried out in other regions of our country. We believe, as stated previously, such slightly different results are due to sociolinguistic variation of our L1 reflecting in our L2 vowel production standards.

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