Discrimination of Californian central vowel contrasts by Spanish-Catalan EFL learners
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Abstract
Spanish and Catalan speakers often face difficulties when learning the English vowel system. Acquisition of English schwa (/ə/) is of particular interest, because Majorcan Catalan has a stressed /ə/ in its phonemic inventory. PAM/PAM-L2 posits that native language experience shapes perception of L2 sounds, so discrimination of L2 contrasts can be predicted from L2-to-L1 categorization. The current study focused on whether discrimination of the vowel contrasts /ɛ/-/ʊ/, /ɛ/-/ʌ/, and /ɛ/-/ʊ/ can be accounted for by the perceptual assimilation of these vowels onto L1-Catalan categories. Spanish-Catalan experienced learners of English performed a categorization with goodness rating task and an AXB discrimination task. The four vowels of interest, /ɛ/, /ʊ/, /ʌ/ and /ʊ/, were perceived as uncategorized and the contrasts involving /ʊ/ differed in the degree of perceptual overlap. Specifically, /ʊ/-/ʊ/ was non-overlapping, /ɛ/-/ʊ/ was partially overlapping, and /ʊ/-/ʊ/ was completely overlapping. Discrimination was poorer for /ʊ/-/ʊ/ than the other two contrasts. However, contrary to PAM predictions, no differences were found between the partially overlapping contrast /ɛ/-/ʊ/ and the non-overlapping contrast /ʊ/-/ʊ/. Overlap scores for individual participants were not related to discrimination accuracy, suggesting that predictions of L2 discrimination based on L2-to-L1 categorization should be made at the group level.

Keywords: L2 perception, vowel discrimination, Californian English, Spanish, Catalan

1. Introduction
While a few studies have examined the difficulties encountered by L1-Spanish-Catalan listeners when discriminating English vowel contrasts [1, 2], no prior study has addressed the perception of vowel contrasts involving schwa (/ə/). In contrast to English, where /ə/ only appears in unstressed position, it is part of the Catalan vowel inventory. The phonemic status of /ə/ varies across dialects. For instance, in Peninsular

Catalan, schwa only appears in unstressed position. In Majorcan Catalan (MC) it can also be stressed [3]. Spanish-Catalan speakers learning English as a FL appear to have difficulties to distinguish English /ə/ and /ʌ/ which are often conflated both in perception and production.

The Perceptual Assimilation Model (PAM) [4] and its extension, PAM-L2 [5], posit that native language experience shapes perception and influences the acquisition of phonological categories in a second language (L2). According to PAM-L2, at the initial stages of L2 learning, the L2 phonemes are either categorized (with varying levels of goodness of fit), perceived as speech but as uncategorizable, or perceived as non-speech (nonassimilable). More recently, Faris et al. [6, 7] suggested that uncategorizable L2 phonemes may be further classified into focalized, clustered, and dispersed (for recent summaries see [8, 9]). An L2 phoneme is focalized when no single L1 category reaches the categorization threshold and no other L1 category is selected more than would be expected by chance. An uncategorized-clustered assimilation occurs when more than one category is selected above chance and uncategorized-dispersed occurs when no label is selected above chance. When uncategorizable L2 phonemes are combined into contrasts, the listener may perceive phonological overlap between them. They are completely overlapping if the same set of L1 categories is perceived for both phonemes, partially overlapping if at least one, but not all L1 categories are in common, and non-overlapping if different sets of L1 categories are perceived for each L2 phoneme. Discrimination accuracy should be highest for non-overlapping contrasts, followed by partially overlapping and completely overlapping contrasts.

Other researchers [10, 11] have used a “cross-language assimilation overlap” to account for the influence of perceived phonological overlap on discrimination of L2 contrasts. The overlap score is obtained by summing the lowest categorization
percentage for each response category. Whereas Faris et al. [7] included only those labels that were selected above chance, the overlap score includes all scores in the categorization task. Levy [11] showed that discrimination of French vowel contrasts by American English learners was correlated with assimilation overlap scores. Other recent work exploring perception of American English vowels by Spanish learners have reported similar findings [1, 12]. Faris et al.’s [7] results were accounted for more effectively by their own method than by the overlap score, but they suggested that further evaluation is required. In this study, we will compare the overlap score with the PAM predictions for perceived phonological overlap.

2. The study

This paper is part of a larger study exploring categorization and discrimination of Californian English (CE) vowels by Spanish-Catalan FL advanced learners. Specifically, we address the categorization of CE ɛ/ɛ, /æ/, /ə/, and /o/ and to what extent discrimination accuracy of the contrasts /ɛ/-/ɔ/, /æ/-/ə/ and /o/-/o/ is influenced by the categorization patterns outlined in [7, 8, 9].

2.1. Method

2.1.1. Vowel stimuli

The full set of Californian English vowels was produced by a 21-year-old female speaker who was born and raised in California. The vowels were embedded in /hVba/ nonwords and elicited using keywords (e.g., hebbα for /ɛ/, huβba for /æ/, hoobα (book) for /ə/, h@bba (the) for /o/). Based on previous studies on vowel perception and production [1, 13], the bilabial context was chosen to reduce coarticulation effects. The best four tokens were selected for inclusion in the test on the basis of acoustic analysis and auditory judgement (see Figure 1).

2.1.2. Participants and procedure

The final sample consisted of 43 Spanish-Catalan bilinguals (mean age = 21.68, SD = 5.44, 38 females, 5 males). All participants reported growing up in either Catalan-speaking (n = 13) or Spanish-speaking households (n = 32). Seven additional participants were tested but their data were removed because they were not Spanish-Catalan bilinguals (n = 4), failed to follow the instructions (n = 2), or had a speech/language disorder (n = 1). The Catalan-dominant participants were exposed to MC from birth and reported speaking this language at home. The Spanish-dominant participants had been exposed to Catalan from the age of 2 or 3 and spoke both languages on a regular basis. The participants were experienced EFL learners with a B2+/C1 level of English, according to the Common European Framework of Reference for Languages, and were given course credit for their participation.

Participants were tested on campus in groups of two or three. The AXB task was administered before the categorization task. They were told that they would hear three h_ _ _ nonwords and they were instructed to choose whether the vowel in the first (A) or third (B) utterance was the same as the vowel in the middle utterance (X). The task was divided in nine separate blocks of 48 trials each, each block testing a different vowel contrast and presented in a counterbalanced order. Only three of the blocks are analyzed here. In the categorization task, listeners were instructed to select the vowel label that most closely matched the vowel in each stimulus utterance, using a grid of Catalan vowels written in IPA script. There were 8 monophthongs (a e i o ñ u) and 24 permissible two-vowel combinations (e.g., ai au). After selecting the label, they rated the goodness of fit using a 7-point scale (1 = a poor fit, 7 = a perfect fit). If the vowel they heard did not fit on any of the response options, they could use three additional options: (1) Not a speech sound (2) Other speech sound. (3) Unknown speech sound and were requested to type a description of what they heard.

Figure 1: Mean formant values at the 50% duration point for each token of the four vowel monophthongs.
2. Results

2.2.1. Categorization

The mean categorization percentages for the vowels of interest, /ɛ/, /ʌ/, /ʊ/, are presented in Table 1. As no single label was chosen above 70%, all four of the vowels are uncategorized. The three contrasts differed in terms of the degree of perceptual overlap. The /ɛ/-/ə/ contrast was partially overlapping because listeners selected MC /a/ above chance for both vowels, but unique labels were also chosen for each vowel. /ɛ/-/ə/ is considered completely overlapping because MC /a/ and /ə/ were the only above-chance labels chosen for both vowels. Finally, the /ʊ/-/ə/ contrast was non-overlapping because there were no above-chance labels in common. PAM contrast assimilation types and overlap scores for each contrast are presented in Table 2.

Table 1: Mean categorization percentages of the four CE vowel monophthongs. Goodness ratings are in parentheses, italic script denotes labels selected above chance, and “Other” is the sum of the two-vowel combinations.

<table>
<thead>
<tr>
<th>Majorcan Catalan vowel category</th>
<th>/ɛ/</th>
<th>/ʌ/</th>
<th>/ʊ/</th>
<th>/ə/</th>
<th>/ʊ/</th>
<th>/ɛ/</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ɛ/-/ə/</td>
<td>40.2</td>
<td>35.0</td>
<td>4.2</td>
<td>0.1</td>
<td>19.5</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>/ʌ/-/ə/</td>
<td>1.5</td>
<td>7.0</td>
<td>66.4</td>
<td>2.1</td>
<td>0.4</td>
<td>0.2</td>
<td>23.1</td>
</tr>
<tr>
<td>/ʊ/-/ə/</td>
<td>(3.6)</td>
<td>(3.6)</td>
<td>(5.5)</td>
<td>(4.4)</td>
<td>(4.2)</td>
<td>(4.0)</td>
<td>(4.9)</td>
</tr>
<tr>
<td>/ə/-/ə/</td>
<td>1.3</td>
<td>0.8</td>
<td>0.4</td>
<td>12.7</td>
<td>38.4</td>
<td>22.5</td>
<td>7.6</td>
</tr>
<tr>
<td>/ə/-/ə/</td>
<td>(3.3)</td>
<td>(4.6)</td>
<td>(3.2)</td>
<td>(4.3)</td>
<td>(4.6)</td>
<td>(4.9)</td>
<td>(4.2)</td>
</tr>
<tr>
<td>/ə/-/ə/</td>
<td>6.0</td>
<td>0.7</td>
<td>7.3</td>
<td>23.8</td>
<td>2.4</td>
<td>1.4</td>
<td>55.9</td>
</tr>
<tr>
<td>/ə/-/ə/</td>
<td>(4.1)</td>
<td>(4.2)</td>
<td>(4.8)</td>
<td>(4.0)</td>
<td>(3.9)</td>
<td>(3.7)</td>
<td>(5.1)</td>
</tr>
</tbody>
</table>

Table 2: Assimilation patterns and percent overlap of the vowel contrasts tested.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>PAM assimilation</th>
<th>% Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ɛ/-/ə/</td>
<td>Uncategorized-Uncategorized</td>
<td>54.5</td>
</tr>
<tr>
<td>/ɛ/-/ə/</td>
<td>Completely overlapping</td>
<td>38.1</td>
</tr>
<tr>
<td>/ɛ/-/ə/</td>
<td>Partially overlapping</td>
<td>15.3</td>
</tr>
<tr>
<td>/ɛ/-/ə/</td>
<td>Non-overlapping</td>
<td>15.3</td>
</tr>
</tbody>
</table>

2.2.2. AXB discrimination

The mean discrimination accuracy for the three vowel contrasts is presented in Figure 2. Listeners showed high accuracy for the /ɛ/-/ə/ and /ʊ/-/ə/ contrasts, with scores that averaged 92.6% (SD = 7.4%) and 90% (SD = 6.3%), respectively. In contrast, discrimination for the /ɛ/-/ə/ contrast was moderate with a mean of 65% (SD = 13.8%). A one-way repeated measures ANOVA with contrast as the within-subjects factor yielded a significant effect of contrast, $F(1,60, 67.3) = 152.72, p < .001, \eta_p^2 = .78$. Pairwise comparisons revealed that the /ɛ/-/ə/ and /ʊ/-/ə/ contrasts were discriminated more accurately than /ɛ/-/ə/ and /ʊ/-/ə/. Discrimination of the /ɛ/-/ə/ and /ʊ/-/ə/ contrasts did not differ significantly from one another.

![Figure 2: Mean discrimination accuracy of the three CE vowel contrasts. Error bars represent standard error of the mean.](image)

2.2.3. The relationship between discrimination accuracy and overlap

Following Levy [11], Spearman rank-order correlations were run to test whether differences in discrimination accuracy are related to an individual’s overlap scores obtained in the categorization of the two vowel categories. None of the three correlations were significant: /ɛ/-/ə/ ($r_{43} = -.286, p = .063$), /ɛ/-/ə/ ($r_{43} = -.142, p = .362$) or /ʊ/-/ə/ ($r_{43} = .049, p = .754$), indicating that discrimination accuracy could not be accounted for by the overlap scores calculated for each individual and for each contrast.

3. Discussion and conclusions

The aim of the present study was to test whether discrimination of the CE contrasts /ɛ/-/ə/, /ʊ/-/ə/ and /ʊ/-/ə/, by a group of experienced Spanish-Catalan learners of English, could be predicted from categorization using Catalan vowel labels. All three contrasts were uncategorized, but they differed in terms of their perceived phonological overlap. Consistent with PAM/PAM-L2, discrimination of the completely overlapping /ɛ/-/ə/ contrast was poorer than the partially overlapping /ɛ/-/ə/ and the non-overlapping /ʊ/-/ə/. However, contrary to PAM/PAM-L2 predictions, there was no difference in
discrimination accuracy for /ɛ/-/ǝ/ and /ʊ/-/ǝ/. It is interesting to note that the partial overlap for /ɛ/-/ǝ/ was only for MC /ǝ/, which was only chosen 19.5% of the time. The other above-chance labels, /ɛ/ and /ǝ/, accounted for 75% of responses. Those labels were not selected above chance for English /ǝ/, which may explain the high accuracy for /ɛ/-/ǝ/.

The lack of significant rank-order correlations between overlap and discrimination scores at the individual level does not parallel prior work that explores the relationship between L2 discrimination and perceptual assimilation in Spanish and Catalan [1, 11, 12]. We speculate that the fact that many listeners’ discrimination accuracy reached ceiling might have contributed to this finding. In any case, our results seem to concur with [7] that predictions of discrimination accuracy based on quantitative overlap scores work better at the group level than at the individual level.

Discrimination was poorest for /ʌ/-/ǝ/, in line with the predictions for perceived phonological overlap. This contrast is also interesting from an L2 acquisition perspective because studies of sound change [14, 15] suggest that the two vowels are undergoing a process of vowel merger in CE. This may be particularly problematic for MC native speakers, in particular, because /ǝ/ is a phonological category in MC. Figure 1 shows a clear separation between the /ʌ/ and /ǝ/ formant values for our speaker, so there should have been sufficient acoustic information for vowel discrimination, but the participants’ prior exposure to other CE speakers who exhibit the merger may exacerbate difficulties with the contrast. Future studies could investigate this further by exploring L2 vowel production in this population.

Finally, participants in this study appear to have performed much better in the AXB task compared to the participants in prior studies testing discrimination of English vowels by listeners in an instructed-learning context [2, 16, 17]. The phonological characteristics of Majorcan Catalan may have contributed to this, along with the opportunities for authentic input from the media and from native speakers visiting the island during the holiday season. They may have developed L2 categories through linguistic exposure and interaction with speakers of the language [18].

4. Acknowledgements

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5. References