Feature-specific advantages in L3 phonological acquisition

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ABSTRACT

Basque and Catalan speakers share similar language profiles: L1 acquired at home (Basque/Catalan or the majority language, Spanish), L2 acquired at the onset of schooling (Spanish or Basque/Catalan), and L3 English acquired later. Due to comparable sociolinguistic environments and differing typologies, these populations are ideal for studying L3 phonological acquisition. Basque and Catalan share fricatives/affricates with English that regional Spanish lacks (e.g. [ʃ,ts]); Catalan shares additional vowels with English (e.g. [ɛ,ə]).

An examination of English vowel and fricative/affricate perception and production by Basque and Catalan speakers showed that while both groups performed similarly in perceiving contrasts, Catalan speakers also demonstrated advantages in production, specifically for [ɛ] and word-final [t-ts]. However, despite Catalan unstressed [ə], Catalan speakers did not demonstrate advantages in perception or production of acoustically-similar [ʌ]. Rather than negative transfer from Spanish, this suggests that L3 learners may demonstrate feature-specific advantages only when phones are contrastive in the L1/L2.

Keywords: L3 phonological acquisition, L3 acquisition, multilingual acquisition, multilingualism

1. INTRODUCTION

Research in the field of third or additional language (L3/Ln) acquisition has generated much recent interest in multilingual language learning as a distinct entity from second language learning. Specific to phonology, L3 learners may have a broadened phonetic repertoire that could assist in overall L3 perception, production, and acquisition.

Models of L2 phonological acquisition may provide a base upon which to build L3 models. The Perceptual Assimilation Model (PAM) and its L2 extension [3] posit that L2 learners categorize and assimilate new, non-native phones through contrast discrimination. A contrast similar to a pre-existing L1 contrast will be more accurately perceived. In the Speech Learning Model (SLM) [13], a sound that is similar to an L1 phone will be perceptually linked to the existing L1 category. If there is no equivalent in the L1, another phonetic category will be created. Sounds similar to existing sounds in the L1 will be more difficult to perceive and produce. Additionally, the Phonological Permeability Model [5], specifically proposed for L3 phonological acquisition, suggests separate mental representations for native and non-native systems; the L2 system is more greatly affected by the acquisition of L3 phones than the L1 system is.

The L1 and L2 may interact with the L3 in different ways. Previous research on L3 acquisition, focusing on lexical and morphosyntactic domains, has found evidence supporting a psychotypological explanation [8, 16]. Linguistic properties from either the L1 or the L2 that show greater cross-linguistic overlap with the L3 may be more susceptible to transfer [25]. Evidence from the phonological domain suggests that speakers may show greater degrees of transfer from the L2 or more recently acquired language [11, 14, 21, 28, 29, 30] or that there is a combined L1/L2 effect [30, 31].

The Basque Country and Catalonia are ideal locations for studying L3 acquisition, due to similar linguistic environments. Populations in both regions are bilingual in Spanish, and the local language (Basque or Catalan) is the language of schooling. Both populations usually encounter English as their first foreign language. Additionally, while Catalan and Spanish are typologically related, Basque is a language isolate; all three languages are relatively typologically distant from English. However, while the phonological system of Basque is similar to that of Spanish, Catalan and English share certain phones or contrasts that both Basque and Spanish lack.

Studies on English vowel acquisition in these regions have found that Catalan speakers perceive and produce English /i, e, ɛ/ as similar to Catalan /i, e, ɛ/. English /ɪ/ was perceived as a poor match to Catalan /e/ and productions of /ɪ/ overlapped with /i/ [6, 7]. Productions of mid-vowel contrasts were found to be robust, but perception was attenuated by language dominance in bilinguals, with Spanish-dominant speakers showing more difficulties [1]. Perception of English vowels and awareness of discrimination difficulties were similar between Basque L1 and Spanish L1 bilinguals [9, 10].

This paper examines L3 English phonological acquisition, considering the relative similarities and differences in phonological systems, with both

consonants and vowels under study. Regarding consonants, Basque and Catalan speakers should be expected to perform similarly regarding fricative and affricate perception and production, as both Basque and Catalan share similar categories with English, which are lacking in regional Spanish.

Differences are expected in performance on English vowels. Catalan speakers, due to experience with a larger vowel inventory overall, may outperform Basque speakers in perceiving and producing *all* English vowel contrasts. However, it is also possible that Catalan speakers will only show advantages when a previously acquired contrast is productive and meaningful in their L1/L2.

2. METHODS

The data come from 13 participants (F=5, M=8) in the Basque Country and 6 participants (F=5, M=1) in Catalonia. The Basque speakers were recruited from San Sebastian (n=9) and Azpeitia (n=4). The tasks were performed in quiet areas provided by the Basque Center on Cognition, Brain and Language and the Azpeitia Municipality. The Catalan speakers were recruited from Barcelona (n=6), and the tasks were performed in a quiet area provided by the Universitat Autònoma de Barcelona or areas familiar to the participant. Productions were recorded using a Zoom H4N Pro portable recorder and an AKG C-520 head-mounted microphone at 44.1kHz.

Participants completed a language background questionnaire [22] to report language learning history, relative input and use of each language, and self-rated proficiency. Participants also completed a cloze test (in Catalan) or lexical decision task (in English [19], Spanish [15], Basque [12]) to obtain objective proficiency scores. All Catalan speakers were L1 Catalan speakers, and Basque speakers were either L1 Basque (n=6) or L1 Spanish (n=7) speakers. All speakers were highly proficient in their L1/L2 and had comparable scores of upper intermediate L3 English proficiency.

2.1. Perception

An ABX task was designed and administered in Praat [4], with /i, ɪ, e(eɪ), ɛ, æ, ɑ, o(oʊ), ʌ/ in /bVt/ context; /s, ʃ, tʃ/ in word-initial /Cɪp/ context; and [t, ts, ʃ, tʃ] in word-final /kæC/ context. Possible responses included both ABA and ABB. Each participant provided 6 ABX ratings per contrast.

The stimuli were recorded by two female, native English speakers, with one speaker providing the stimuli for AB and the other for X. The use of two voices requires participants to abstract some features of the stimulus, rather than listen for exact repetitions of the acoustic signal.

2.2. Production

A non-word repetition task was designed and administered in Praat. The production task was administered at least 24 hours after the perception task. Participants first heard /i, ɪ, e(eɪ), ɛ, æ, ʌ, ɑ, o(oʊ), ʊ, u/ in /hVd/ context and were asked to repeat the word but change the final consonant from [d] to [b]. Following previous methodology [26], this minimizes tongue coarticulation and requires participants to abstract phonemic vowel categories.

Vowels were manually segmented in Praat using standard measurement criteria [23]. F1 and F2 values were extracted automatically at the midpoint of the vowel and manually checked for accuracy. All formant data were normalized with the Lobanov method, using the *vowels* package [17] in R [24].

Secondly, participants heard [t, ts, ʃ, tʃ] in word-final /mæC/ and /bæC/ contexts. They were asked to change the first letter of the word to [d], regardless of the initial consonant that they heard. Recordings were manually transcribed for accuracy.

2.3. Statistical analyses

For the ABX perception results, responses were analyzed with binomial logistic regressions using *glm* in R. More complex binomial mixed effects regressions failed to converge. Linear mixed effects regressions were run on formant values with the function *lmer* in the package *lme4* [2]. P-values were obtained with the Satterthwaite approximation in *lmerTest* [18]. Productions of word-final fricatives and affricates were also analyzed with binomial logistic regressions. Details regarding the structure of the regressions are given in the results section.

3. RESULTS

3.1. Perception

A binomial logistic regression was run on the ABX responses to the trials testing fricative and affricate contrasts, with Contrast (7 levels), Language (2 levels: Basque, Catalan), and their interaction as fixed effects. The output of the regression showed significant differences in perception of word-final [t-ts] (β= -2.703, z= -3.560, $p<0.001$), and between Basque and Catalan speakers in perception of the same contrast (β=2.379, z=2.139, $p<0.05$). Word-final [t-ts] perception was significantly worse, specifically for Basque speakers.

A second binomial logistic regression was run on the ABX responses to the trials testing vowel contrasts, with Contrast (12 levels), Language (2 levels), and their interaction as fixed effects. The output of the regression showed significant

differences among accuracy with certain vowel contrasts: /e-æ/ (β=2.909, z=2.770, p<0.01) and /o-ʌ/ (β=2.909, z=2.779, p<0.01), with significantly higher accuracy; and /ɛ-æ/ (β= -0.910, z= -2.456, p<0.05), /i-e/ (β= -0.180, z= -4.884, p<0.0001), /ɪ-e/ (β= -0.742, z= -1.981, p<0.05), with significantly lower accuracy. Differences between language groups were not significant.

3.2. Production

For fricative and affricate productions, binomial logistic regressions were run on each individual target consonant, due to performance near or at ceiling for all consonants and the resulting quasi perfect separation of the accuracy measure. There were no significant differences between Basque and Catalan speakers. The only result that approached significance (β=1.067, z=1.874, p=0.061) included the combination of word-final [t] in the experimental items and in filler words that ended in [t].

Figure 1 (made with the package *ggplot2* [27]) shows the vowel plot of target English vowels by Basque speakers. A visual inspection of the plot shows an overlap in the vowel spaces of the front vowels and of the back vowels. There is some overlap in the productions of /i, e, ɪ, ɛ/, while /ɑ, ʌ/ show an almost complete overlap.

Figure 1: Productions of English vowels by Basque speakers. Formant data have been rescaled to Hertz-like values for presentation clarity only.

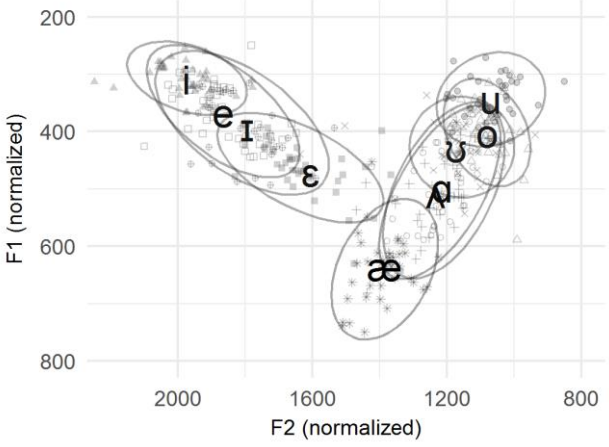
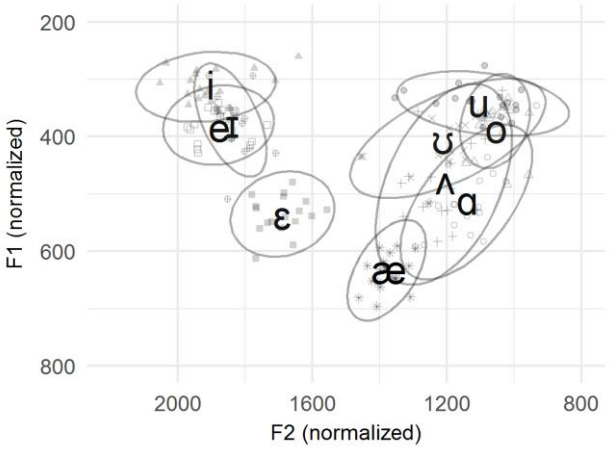


Figure 2 shows the vowel plot of target English vowels by Catalan speakers. A visual inspection of the plot shows that while there is some overlap between /i, e, ɪ/, /ɛ/ occupies a completely separate space. There is some overlap between /ɑ, ʌ/.

Two linear mixed effects regressions were run on F1 and F2, with Vowel (10 levels), Language (2 levels: Basque, Catalan), and their interaction as fixed factors, and Speaker as a random factor.

Figure 2: Productions of English vowels by Catalan speakers. Formant data have been rescaled to Hertz-like values for presentation clarity only.



The regression output showed significant differences among all vowels (p<0.001) as well as a significant difference for productions of [ɛ] between Basque and Catalan speakers for F1, or vowel height (β=0.67, t=3.4, p<0.001) and F2, or vowel backness (β=0.67, t=3.4, p<0.05). Post-hoc comparisons, using the *emmeans* package [20], also returned significant differences between Basque and Catalan speakers in vowel height for /ɛ/ (p<0.001) and /ʌ/ (p<0.05); and in vowel backness for /ɛ/ (p<0.01), /ɑ/ (p<0.01) and /i/ (p<0.01). Within language, post-hoc comparisons are summarized in Tables 1 and 2.

Table 1: Post-hoc comparisons for formant values of Basque speakers.

	F1		F2	
Contrast	Coef. β	p-value	Coef. β	p-value
i - e	0.538	<0.001	-0.323	<0.001
i - ɪ	-0.771	<0.001	0.531	<0.001
e - ɪ	-0.232	0.509	0.208	0.039
ɛ - e	-0.976	<0.001	0.757	<0.001
ɛ - ɪ	0.743	<0.001	-0.549	<0.001
ʌ - ɑ	0.092	0.998	0.058	0.996
ʌ - ʊ	0.755	<0.001	0.175	0.159
o - ɑ	0.906	<0.001	0.394	<0.001
o - u	0.556	<0.001	0.026	1.000
o - ʊ	-0.242	0.448	-0.277	<0.001
u - ʊ	-0.798	<0.001	-0.304	<0.001

Results show that, while productions of /e/ and /ɪ/ do not differ significantly for vowel height or backness, they both differ significantly from /i/ and from /ɛ/. /ʌ/ does not differ significantly from nearby /ɑ/ or /ʊ/ in vowel backness but does differ from /ʊ/ in height. The back vowels differ significantly from one another in either vowel height or backness, with /u - ʊ/ differing in both dimensions.

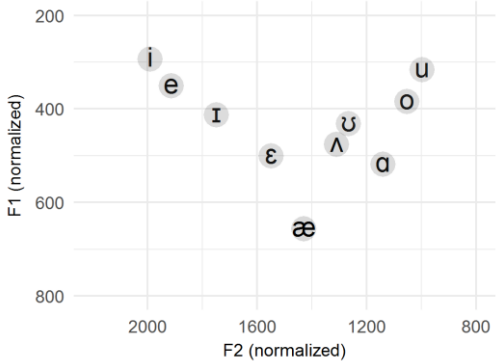
Table 2: Post-hoc comparisons for formant values of Catalan speakers.

	F1		F2	
Contrast	Coef. β	p-value	Coef. β	p-value
i - e	0.693	<0.01	-0.074	0.999
i - ɪ	-0.627	<0.01	0.188	0.592
e - ɪ	0.065	1.000	0.114	0.970
ɛ - e	-1.448	<0.001	0.543	<0.001
ɛ - ɪ	1.513	<0.001	-0.429	<0.001
ʌ - ɑ	-0.334	0.543	0.196	0.537
ʌ - ʊ	0.671	<0.001	-0.019	1.000
o - ɑ	1.178	<0.001	0.250	0.189
o - u	0.425	0.200	-0.152	0.834
o - ʊ	-0.171	0.988	-0.466	<0.001
u - ʊ	-0.597	<0.01	-0.313	<0.05

Results for Catalan productions also show that /e/ and /ɪ/ do not differ significantly for vowel height or backness, and that both are significantly different from /ɛ/. However, /e, ɪ/ differ from /i/ in vowel height only. Results for /ʌ/ mirror those of the Basque speakers, with /ʌ/ differing significantly from /ʊ/ in height only. Back vowels /o-u/ do not differ from each other, /o-ʊ/ differ only in vowel height, and /u-ʊ/ differ in height and backness.

Regarding /ɑ/ and its overlap with /ʌ/, it is important to note that the speaker who provided the stimuli for the production task exhibited the *cot-caught* merger, so the phoneme transcribed as /ɑ/ is actually a low-mid vowel and occupies, in part, the phonetic space of [ɔ]. Figure 3 shows the stimuli vowel plot, normed with participant productions.

Figure 3: Vowel plot of the task stimuli, rescaled to Hertz-like values for presentation clarity only.



It is possible that listeners perceived and produced the speaker's /ɑ/ as a back mid vowel. Productions of /ɑ/ differ significantly from /o/ in F1 for Catalan speakers, and in F1 and F2 for Basque speakers.

4. DISCUSSION AND CONCLUSION

The perception and production data of Basque and Catalan speakers showed key differences in their acquisition of L3 English. While both groups were near or at ceiling for perception of word-initial and word-final fricative and affricate contrasts, Basque speakers as a group showed significantly more difficulty with the word-final [t-ts] contrast.

Differences in productions of word-final [t] approached but did not reach significance between language groups. It is worth noting that errors with [t] were almost always [ts] productions; aspiration of the final stop, always present in the English stimuli, may have been misinterpreted as frication. Although word-final [t, ts] do occur in high frequency Basque words, e.g. *dit* 'abs-AUX-dat-1s-erg-3s' (*esan dit* 's/he told me [something]') and *hitz* 'word', the Catalan word-final [t-ts] contrast closely mirrors the English contrast, e.g. *gat* 'cat', *gats* 'cats'.

No significant differences were found between groups in the perception of vowel contrasts, but there were differences in production. While Basque productions of English /ɛ/ were significantly different from their productions of /e, ɪ/, there was some overlap among the three phones. Catalan productions of /ɛ/, on the other hand, showed no overlap with /e, ɪ/. The patterns found for Catalan speakers align with previous studies [1, 6, 7].

Furthermore, despite the presence of unstressed [ə] in Catalan and a wider vowel inventory overall, Catalan speakers did not demonstrate advantages over Basque speakers in the perception or production of acoustically-similar [ʌ]. Productions of /ʌ/ overlapped almost entirely with /ɑ/. Results suggest that for both groups, a new category may have been created for /ɑ, ɔ/, but /ʌ/ was not perceptually or articulatorily different enough to warrant an additional category, or vice versa.

Catalan speakers also did not demonstrate an advantage over Basque speakers in perception or production of back vowel contrasts that do not exist in the L1/L2. Productions of /ɑ/ and /o/ were distinct for both groups, and productions of /ʊ/ by both groups were significantly different from /u/. This may possibly be attributed to their upper intermediate levels of English proficiency.

The results suggest that learners do not transfer all of their phonological knowledge from a previously-acquired language, even if that knowledge would be beneficial to the learner. For example, Basque speakers who have word-final [t, ts] in Basque still demonstrate difficulties with English contrasts, and Catalan speakers still demonstrate difficulties in producing native-like English /ʌ, ə/. Only some L3 phones (/ɛ/) were categorized and assimilated accurately to L1/L2 categories (as PAM, SLM would predict). L3 learners may therefore demonstrate an advantage only when phones are meaningfully contrastive in the L1/L2. As such, this advantage is proposed to be feature-specific for L3 phonological acquisition.

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