

Interaction of L2 Phonotactics and L1 Syllable Structure in L2 Vowel Production

Juli Cebrian

Universitat Autònoma de Barcelona, Spain

juli.cebrian@uab.es

1. Introduction

In addition to learning the phonemic inventory and phonetic variants, second language (L2) learners also face the task of learning the prosodic structure and phonotactic constraints of the target language. As is the case with segmental structure, the acquisition of suprasegmental structure is subject to the interference from the first or native language (L1), among other factors. Studies have shown that L1 syllable structure, phonotactics and stress patterns are carried over to the L2 (Tarone, 1987; Chela-Flores, 1996; Sato, 1984; Broselow, 1987; Onishi et al., 2002, among others). For instance, differences in syllabification between the L1 and the L2 have been found to result in inaccurate pronunciation of L2 sequences (Trammell, 1993; Delattre, 1965). Further, Rochet and Putnam Rochet (1999) found that the phonotactic constraint that governs the distribution of the high and mid front unrounded vowels in French (/i/, /e/ and /ɛ/) affects French speakers' pronunciation of English /ɪ/.

The current study addresses this issue by focusing on the acquisition of L2 phonotactic constraints and syllabification processes and how this knowledge influences the acquisition of L2 sounds. The acquisition of the English tense-lax contrast provides an opportunity for investigating this issue. This is because the contrast between English lax and tense vowels is partly based on nonsegmental information. The English Lax Vowel Constraint (LVC) restricts lax vowels, but not tense vowels, to closed syllables. Evidence for the LVC can be found in the treatment of borrowings into English and in English accent in foreign languages (Solé, 1989; Westby, 1984). For example, the English pronunciation of the French word "gourmet", which ends in a lax vowel in an open syllable ([ɛ]), is "gourm[ej]", with a final tense vowel. Further evidence comes from the syllabification of medial consonants, as discussed below.

The LVC is a novel nonsegmental feature for the Catalan learner of English. English and Catalan differ also in syllable structure, including the treatment of intervocalic consonants. Catalan has well defined syllable boundaries, and the syllabification of a single medial consonant always obeys onset maximization (Recasens, 1993). In English syllable boundaries are less clear and the syllabification of intervocalic consonants is affected by a number of factors including the quality of the preceding vowel (Westby, 1984; Fallows, 1981; Treiman & Danis, 1988; Treiman & Zukowski, 1990; Derwing, 1992). These studies show that English speakers favour the syllabification of a medial consonant in the coda (or ambisyllabic) when the previous vowel is lax (e.g., lem-on), but not when it is tense (e.g., demon).

This study investigates the acquisition of segmental as well as nonsegmental structure by looking at the acquisition of the English tense-lax contrast by native speakers of Catalan, a language with no segmental tense-lax contrast and no syllabic restrictions on vowels. The goals of the paper are thus (1) to examine if phonotactic constraints such as the LVC are acquired by L2 learners, (2) to evaluate the interaction between knowledge of the LVC and syllabification of medial consonants in the L2, and (3) to assess how this interaction may affect L2 vowel production. The learners' knowledge of the LVC and of English syllabification patterns is tested in a series of picture naming and syllabification tasks

(experiments 1 and 2). The results of these experiments are then contrasted with the learners' production of the English /i/-/ɪ/ and /ej/- /ɛ/ contrasts (experiment 3).

2. Experiment 1: Picture naming task

The goal of this experiment was to test the L2 English learners' knowledge and productivity of the LVC.

2.1 Participants

The participants were 30 Catalan learners of English who were upper level English-major undergraduate students at a university in Barcelona. The students had completed a course on English phonetics and were exposed to native English from different varieties in their degree but had limited L2 input outside the classroom. These students had participated in a perception experiment where they obtained very high rates of correct identification of English high and mid front vowels (around 90%) (Cebrian, 2005). A group of 25 native speakers of Canadian English were also tested.

2.2 Tasks

The participants performed a singular derivation (SD) task and a template matching (TM) task. The tasks involved matching a given aural stimulus with a picture presented on a computer screen by means of inserting the aural stimulus in a carrier sentence that described the picture. The test stimuli were recorded from a male native speaker of American English. In the SD task participants had to provide the singular form of a given word by inserting it in the carrier sentence "And here is one ____". The words were non-sense words with three possible endings: consonant + /s/ or /z/, tense vowel + /z/, lax vowel + /z/ (e.g., /frɛlz/, /teɪz/, /gɪz/). The crucial test words were those ending in a vowel + /z/. In the TM task participants were presented with two words aurally and they had to insert them without modification in the carrier sentence "Here are two ____, the one on the left is called ____". The task thus involved using one word as a singular form and the other word as a plural form. The crucial test items were word pairs consisting of a word ending in a lax vowel + /z/ and a word ending in a tense vowel + /z/. The order of presentation of the words in the pairs was randomized. The two tasks were preceded by a practice session that included regular English plural forms (e.g., cats, dogs) as well as irregular forms (e.g., sheep, deer). The purpose of the tasks was to see if participants would treat the words ending in a lax vowel + /z/ and words ending in a tense vowel + /z/ differently. In the case of the words containing a lax vowel, subtracting the /z/ to form the singular would result in a violation of the LVC. Alternatively, if participants left the word unchanged by analogy to pairs like "one sheep-two sheep", the LVC would be obeyed. The results were analyzed in terms of the number of responses that did not violate the LVC, that is, that did not involve leaving the lax vowel in an open syllable, as illustrated in Table 1.

Table 1. Examples of responses obeying the LVC in the SC and TM tasks

Task	Test words	LVC-obeying response
Singular derivation	[grɛz]	<i>And here is one [grɛz]</i> (not <i>Here is one [grɛ]</i>)
Template matching	[gɪz], [spɪz]	<i>Here are two [spɪz], the one on the left is called [gɪz]</i> (not <i>Here are two [gɪz]</i>)

2.3 Results

The results for the two tasks are summarized in Figure 1, which shows the percentage of responses that obeyed the LVC, in other words, that involved an analysis of the words ending in lax vowel + /z/ as monomorphemic words. Analyses of variance run on the effect of L1 (English vs. Catalan) and type of word (ending in tense vowel +/z/ vs. ending in lax vowel + /z/) in the SD task and on L1 and order of presentation (tense-vowel-word first vs. lax-vowel-word first) in the TM task indicated that the two groups differed significantly in both tasks ($F(1,10)=24.13$, $p<.001$ for the SD task, $F(1,53)17.87$, $p<.001$ for the TM task). The results also showed that both groups formed singular words by subtracting the final /z/ more frequently with words containing tense vowels than with words containing lax vowels, but the difference was greater in the case of native English speakers.

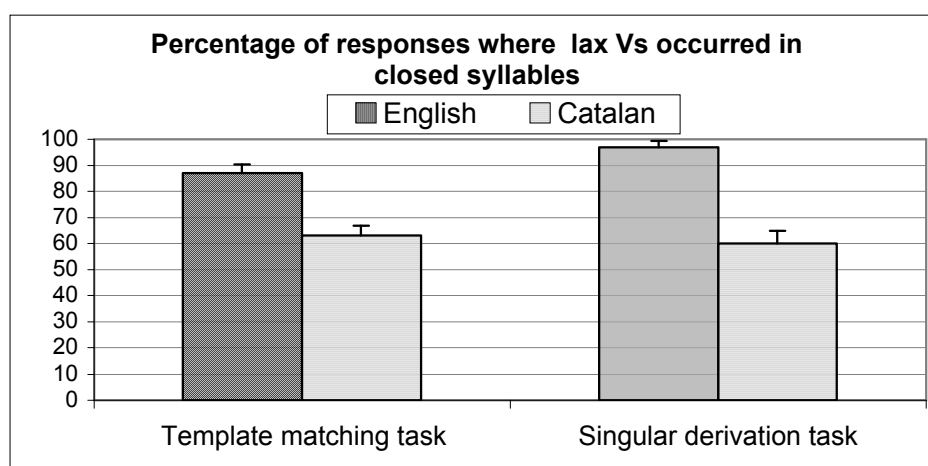


Figure 1. Results of the picture naming tasks for English native speakers and Catalan learners of English

These results illustrate that the LVC is a productive constraint for native English speakers, in agreement with previous works (Wallner, 1986; Westby, 1984). L2 learners' responses also seem to be guided by the LVC, reaching around 60% (above chance) LVC-obeying responses, although this tendency is not as strong as with native speakers. Nevertheless, the learners seem to have some knowledge of the LVC. The way this knowledge may affect the syllabification of medial consonants is explored in Experiment 2.

3. Experiment 2: Syllabification tasks

The goal of this experiment was to test whether native English speakers and Catalan learners of English differ in syllabification strategies and to examine if and how knowledge of the LVC affected syllabification of medial consonants. The participants were the same as in Experiment 1.

3.1 Tasks

The tasks were two syllable manipulation tasks: a Repetition task and a Reverse Order task. In the first task participants were asked to repeat the first "part" of the word, while in the second task they were asked to reverse the order of the "parts" of the word. The practice session in each case involved words with two intervocalic consonants and clear syllable

boundaries. The crucial test words involved words with a single intervocalic consonant. The test words were real English words elicited from a male native speaker of American English. The purpose of the test was to examine if participants would treat words differently depending on the type of vowel preceding the medial consonant. As discussed above, according to the LVC, the medial consonant should be syllabified with the preceding vowel if the vowel was lax. This should not affect words with tense vowels. Table 2 illustrates the task methodology and the possible responses for a critical item.

Table 2. Methodology and possible responses in the syllable manipulation tasks

	Oral stimulus	Response	
		Repetition task	Reverse order task
Examples:	napkin velvet	nap -napkin vel -velvet	kin nap vet vel
Critical item:	limit	lim -limit (obeys the LVC) li -limit (violates the LVC)	(m)it-lim (obeys the LVC) mit-li (violates the LVC)

3.2 Results

The percentage of responses involving syllabification of the medial consonant with the preceding vowel are given in Table 3. Using percentage of CVC-VC breaks as the dependent measure, analyses of variance were conducted examining the effect of L1 (English vs. Catalan) and vowel type (words with a tense vowel vs. words with a lax vowel) for each task. The results showed that the two groups differed significantly in both tasks ($F(1,53)=24.83$, $p<.001$ and $F(1,53)=63.26$, $p<.001$). Word type also reached significance, as did the two-way interactions.

Table 3. Percentage of CVC-VC syllabification responses for words with tense and lax vowels in the syllable manipulation tasks (s.d. are given in parentheses)

Group	Repetition task		Reverse order task	
	tense V word	lax V word	tense V word	lax V word
L1 English	38 (29)	82 (31)	37 (25)	73 (32)
L1 Catalan	19 (29)	23 (35)	8 (18)	7 (20)

The results indicate that native English speakers show a strong effect of vowel type in the syllabification of medial consonants, in agreement with previous studies (Westby, 1984; Fallows, 1981; Treiman & Danis, 1988; Treiman & Zukowski, 1990; Derwing, 1992). This tendency is not present with the Catalan learners of English who show no effect of vowel type and mostly syllabify according to L1 patterns of onset maximization. Therefore, although learners appear to have some knowledge of LVC, this knowledge does not translate into more English-like syllabification. How this relates to their production of tense and lax vowels in different syllabic environments is explored in the third experiment.

4. Experiment 3: Production

The participants were the same as in the previous two experiments. The goal was to investigate if knowledge of the LVC and interference from L1 syllabification have an influence on the production of the tense-lax vowel contrast. This was done by testing vowel production in two environments: CVC monosyllabic words and stress-initial CVCVC

bisyllabic words. Following the results of experiment 2, we can predict that Catalans will syllabify a CVCVC sequence as CV-CVC regardless of the type of vowel preceding the medial consonant. This syllabification leaves this vowel in an open syllable. Experiment 1 has shown that the LVC plays some role in the learners' phonology. The aim of eliciting the learners' production in these two environments was to elicit the production of lax (and tense) vowels in a closed syllable (CVC words) and in a potentially open syllable (e.g., the first vowel in CVCVC words).

4.1 Task

The task was a repetition and insertion task. Subjects heard and then repeated a 'h_d' word and then produced new sets of words by inserting the vowel in the h_d word in the nonsense word frames 'h_b' and 'h_pus' (e.g., 'hid', 'h[ɪ]b', 'h[ɪ]pus'). This method was used to avoid orthographic interference and word frequency effects and to minimize C to V and V to C tongue coarticulation and L1-based weakening effects on intervocalic voiced consonants. The target vowels examined were English /i, ɪ, ej, ε/. Catalan learners of English have been found to have trouble perceiving the /i/-ɪ/ contrast but not the /ej-/ε/ contrast (Cebrian, 2006).

4.2 Results

L2 production was measured by means of acoustic analyses of first and second formants and native speaker judgements obtained by means of an identification task and a goodness ratings task. For the sake of brevity and simplicity, only a summary of the main results is given here (see Cebrian (2007) for more details). Both the acoustic measurements and the native speaker judgements indicated that English /ej/ and /ε/ were the most accurately produced vowels. In the case of /ej/ Catalans obtained a mean identification score of 99% and a mean goodness rating of 5.4 out of 7. The lax vowel /ε/ was correctly identified 88% of the time and was given a mean rating of 5.1. These results are in accordance with the earlier finding that these vowels are strongly assimilated to Catalan /ε/ and /ei/ and pattern as near-identical L1-L2 categories (Cebrian, 2006, 2007). Importantly, pronunciation of the lax vowel /ε/ did not vary across word types.

With respect to /i/ and /ɪ/, the mean identification scores were 77% and 70%, respectively, and the goodness of fit ratings obtained were 4.6 and 3.9 out of 7, respectively. Production of these vowels was therefore less accurate. Although an analysis of word type did not reveal significant differences, identification scores for the lax vowel /ɪ/ were numerically lower in the bisyllabic word (65%) than in the monosyllabic context (72%). Interestingly, when /ɪ/ was not identified as an example of the intended vowel, it was most often heard as /ε/ in monosyllables and as /i/ in bisyllables. The acoustic analysis showed more evidence in this direction. There was some overlap in F1-F2 space for /i/ and /ɪ/ in monosyllabic environment, but this overlap was greatest in bisyllabic environment. Further, the lax vowel /ɪ/ was produced with lower F1 values (i.e., more /i/-like) in bisyllables. Taken together, the pattern of misidentifications for /ɪ/ and the more /i/-like characteristics in bisyllabic environment suggest an effect of word type on the production of this vowel. Importantly, the difference in the pronunciation of the lax vowel in the two environments underscores the need to take suprasegmental structure into account when evaluating segmental production, as discussed below.

5. Discussion and conclusions

This paper explored the interaction between L2 phonotactics and L1 syllable structure in the acquisition of a L2 segmental contrast. Experiment 1 showed that the L2 learners display some knowledge of the LVC, although to a lesser extent than native speakers. Experiment 2 evidenced that knowledge of the LVC does not result in target-like syllabification of medial consonants. Whereas native English speakers resort to coda syllabifications of intervocalic consonants in order to prevent a lax vowel from occurring in an open syllable, Catalan learners of English syllabify English words following L1 principles. The interaction of this partial knowledge of the constraint and the use of L1 syllabification strategies was explored by testing the production of the English tense-lax vowel contrast in CVC and CVCVC words. Although the analyses did not show a main effect of word type, the native speaker judgements indicated a greater tendency on the part of the learners to mispronounce /ɪ/ as /i/ in CVCVC than in CVC context. This tendency was confirmed by the fact that /ɪ/ was produced with more /i/-like acoustic properties in bisyllabic environment than in monosyllabic words. Given that Catalans break English CVCVC words after the first vowel, and that they were found to have some knowledge of the LVC, the mispronunciations of /ɪ/ as /i/ can be interpreted as a “tensing” strategy to avoid having a lax vowel in an open syllable. This is in fact the mechanism that native speakers use in the adaptation of foreign words, as exemplified by the pronunciation of French “gourm[ɛ]” as “gourm[ej]”, or Spanish “San Jose” as “San Jos[ej]”. Importantly, this “tensing” effect in bisyllables indicates that a specific type of segmental error can be the result of non-segmental factors such as the joint effect of L1 and L2 phonotactic and syllabic structure. The lack of a stronger effect of word type and the moderate productivity of the LVC among the learners needs to be examined further by analyzing individual data.

To conclude, this study has shown that the LVC is a productive constraint in L1 English and affects syllabification of medial consonants. With respect to L2 English, there is evidence of some knowledge of the phonotactic constraint. However, interference from L1 syllabification patterns may restrict the ability to apply the LVC in bisyllables, resulting in a greater number of /i/ for /ɪ/ errors in CVCVC context. This kind of context-dependent segmental error indicates that a complete assessment of the acquisition of a given segmental contrast requires the evaluation of data from different prosodic and syllabic contexts.

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