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Spanish EFL learners' categorization of /i:-ɪ/ and phonological short-term memory

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Abstract

This study examined the role of phonological-short-term memory (PSTM) in the weighting of spectral and duration cues in the perception of the English vowel contrast /i:-ɪ/ by Spanish English foreign language (EFL) learners ($N=31$). Cue-weighting was assessed through a perceptual categorization task with natural and manipulated word stimuli. A serial nonword recognition (SNWR) task was used to obtain a measure of PSTM. The results showed that Spanish EFL learners over-relied on duration in the categorization of /i:-ɪ/. However, when controlling for inter-subject differences in proficiency, learners with higher PSTM capacity used duration as a cue in categorization to a lesser extent than learners with lower PSTM capacity. This suggests that PSTM plays an important role in learners' development of target-like cue-weighting.

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1. Introduction

1.1. Individual differences in L2 speech learning

The perception and production of second language (L2) sounds might pose a challenge to language foreign learners at different levels of L2 competence. Although to date, the causes of inter-learner variation are not fully-understood, research on L2 phonological development has identified several aspects that might account for differences in L2 speech learning. L1 background, age of onset of L2 learning, L2 exposure and amount of L1/L2 use among others have been shown to play an important role in L2 phonological competence in immigrant populations (Baker & Trofimovich, 2005; Moyer, 2009). In student populations learning a foreign language, research has predominantly focused on learning contexts effects on L2 phonological development, such as the differential gains of classroom instruction vs. short-term immersion. These studies show modest gains in L2 phonology with mixed results as to which context provides greater gains (Muñoz & Llanes, 2014). Motivation, personality (extroversion/introversion), musical ability, sound processing skills (auditory, acuity, frequency discrimination), imitation skills (aptitude for oral mimicry), and cognitive skills (memory, attention and inhibition) might constitute another source of inter-learner variation in L2 phonological acquisition (Christiner & Reiterer, 2013). Cognitive factors (memory, attention and inhibition) have been shown to be related to L2 phonological development, yet the exact role they play remains unclear at present.

1.2. PSTM and L2 acquisition

Following Baddeley's model of memory, PSTM can be broadly defined as the ability to process auditory traces that start to decay after 2 seconds approximately, unless refreshed through an articulatory rehearsal mechanism before they are stored in long-term memory (Baddeley & Hitch, 1974; Baddeley, 1986, 2003). Studies tapping into PSTM and L1 and L2 acquisition have suggested that PSTM makes an important contribution to the acquisition of L1 vocabulary, grammar, overall competence in language production, and L2 oral fluency (Adams & Gathercole, 2000; O'Brien, Segalowitz, Collentine & Freed, 2007). Although PSTM and its possible relationship with L2 phonological development is still under-researched, some studies have suggested that such relationship might exist. Mackay, Meador & Flege (2001) examined 72 native speakers' perception of English consonants in noise, assessing PSTM via nonword repetition. This study showed that errors in consonant identification were negatively correlated with PSTM scores, and that PSTM accounted for 15% of the variance in the subjects' identification of word-final consonants. The conclusion was that PSTM might influence the perception of L2 consonants by facilitating representations in long-term memory. Cerviño & Mora (2011) investigated L2 vowel cue-weighting skills of Catalan/Spanish bilingual learners of English, assessed through learners' degree of reliance on duration in a forced-choice identification task based on 8-step feet-fit duration continua. They assessed PSTM through a SNWR task. The study indicated that subjects classified as Low-PSTM used duration as a cue in the identification of feet-fit to a greater extent than subjects classified as High-PSTM. It was concluded that PSTM might influence the perception of L2 vowels, in that high PSTM capacity learners might have an advantage in acquiring target-like cue-weighting in vowels.

Abundant studies have shown that Spanish EFL learners mainly rely on duration in the categorization of English /i:/-/ɪ/ (Morrison, 2009) in contrast with native English speakers, who rely mainly on vowel quality or a combination of quality and duration in the perception of this contrast (Ylinen, Uther, Latyala, Vepsäläinen, Iverson, Akahane-Yamada & Näätänen, 2009). In order to perceive and ultimately produce L2 vowel contrasts in a native-like manner, it is necessary to establish representations of vowel categories in long-term memory (Flege, 1995). To the best of our knowledge, the relationship between L2 perception and PSTM has not been sufficiently explored in the literature. The aim of the present study is to shed further light into Spanish EFL learners' cue-weighting of /i:/-/ɪ/, and investigate the role of PTSM in the development of these vowel categories.

2. Method

2.1. Participants

The participants in this study were 31 Spanish EFL learners taking a degree in *English Studies* at a Spanish university (*mean age*= 22.23). The learners, who were given course credit for participating in the experiment, filled in a language background questionnaire and reported to have normal hearing and no speech-related dysfunctions. The following tasks were administered: a perceptual categorization task, a SNWR task, and an L2 vocabulary size test.

2.2. Perceptual categorization task

Cue-weighting in the categorization of /i:-ɪ/ was assessed through a perceptual categorization task (Moya-Galé & Mora, 2011). The participants were presented with 6 minimal pairs (12 words) contrasting /i:-ɪ/ before word-final voiced and voiceless consonants (/b_d/, /d_d/, /s_d/, /b_t/, /p_k/, /p_t/). The tokens were recorded by 10 native talkers of Southern British English from which 6 (3 male and 3 female) were selected, based on voice quality and intelligibility criteria. These talkers produced significant differences in F1, F2 and duration between /i:/ and /ɪ/. Two types of stimuli were presented, natural and manipulated. The manipulation of the stimuli consisted in giving the tense vowel the duration values of its lax counterpart, and vice-versa, within each minimal pair produced by every talker (see Table 1). Manipulated stimuli served as a measure of amount of reliance on duration in the categorization of /i:-ɪ/. In total, the task consisted of 144 trials (12 words x 6 speakers x 2 stimuli types).

Table 1. Duration values for /i:-ɪ/ stimuli.

Context	Natural	Shortening/Lengthening	Manipulated
Voiced	671ms /bi:d/	671ms → 315ms	/bi:d/ 315ms
	307ms /bɪd/	307ms → 658ms	/bɪd/ 658ms
Unvoiced	150ms /pi:k/	150ms → 63ms	/pi:k/ 63ms
	60ms /pɪk/	60ms → 98ms	/pɪk/ 98ms

The stimuli were presented in randomized order both aurally over headphones and in their written form on the computer screen (*beat –bit*). They were given instructions to click on the word they thought they had heard (e.g., *beat*).

2.3. SNWR

SNWR was chosen to test PSTM for two main reasons. Firstly, it lacks an articulatory component that might add difficulty to the task, as is the case for nonword repetition; and secondly, it has been found to minimize the effects of lexical influence on the phonological store (O'Brien et al., 2007). PSTM has been traditionally tested with words and/or nonwords in the L1 however, in the present study, it is tested with nonwords, in a language unknown to the participants (L0). Danish was chosen because it has a large enough vowel inventory (16), to allow for the selection of 7 different vowels. /i, y, ε, œ, a, o, u/ were selected after auditory evaluation by 3 trained phoneticians by considering their cross-language mappings to Spanish vowels /i, e, a, o, u/, so that five Danish vowels (/i, ε, a, o, u/) would closely resemble the Spanish vowels /i, e, a, o, u/ and the remaining two Danish vowels (/œ, y/) would feature acoustic properties (lip rounding on a front articulation) that would be unfamiliar to Spanish speakers, with the objective of preventing possible sequence recollection. CVC nonword sequences were created so that the nonwords in a sequence contained a different vowel and as many different pre-vocalic and post-vocalic consonants as possible. The task consisted of 144 nonwords conforming to Danish phonotactics, which were recorded by a

female native speaker of Danish in a sound-proof booth. The 144 items were organized into 5, 6, and 7 sequence lengths, each containing 4 same and 4 different trials (see Table 2), making up a total of 24 trials. In the different trials, two items were transposed (transposition at the beginning and end of the sequences was avoided). The inter-stimulus interval was 500 ms. between nonwords, 1000 ms. between nonword sequences, and 1500 ms. between sequence pairs.

Table 2. Example of same and different 6- item trials.

6 ITEMS	1	2	3	4	5	6
S	fål	tyk	his	mus	tek	Ryk
S	fål	tyk	his	mus	tek	ryk
D	syd	hul	sæl	hus	dis	jøk
D	syd	hul	hus	sæl	dis	jøk

The participants were given instructions to press a button labeled “same” if they heard two identical sequences, and a button labeled “different” if they heard two different ones. Practice trials were provided, and the test would begin when the researchers had made sure the task was fully-understood.

2.4. Vocabulary size test (*X/Y-Lex*)

This test provides a measure of L2 English vocabulary size (0-10,000 words), and includes L2 nonwords to control for response reliability. It has been shown to correlate with the Oxford Placement Test (Meara, 2005; Miralpeix & Meara, 2006; Miralpeix, 2009). The participants were asked to click on a “happy face” icon if they knew the meaning of the words presented on the computer screen, and on a “sad face” icon if they did not.

3. Results and discussion

The results of the perceptual categorization task revealed that the participants obtained higher scores in the categorization of natural stimuli than in the categorization of manipulated stimuli (see Figure 1), with tense /i:/ and lax /ɪ/ being perceived at similar accuracy rates (see Table 3).

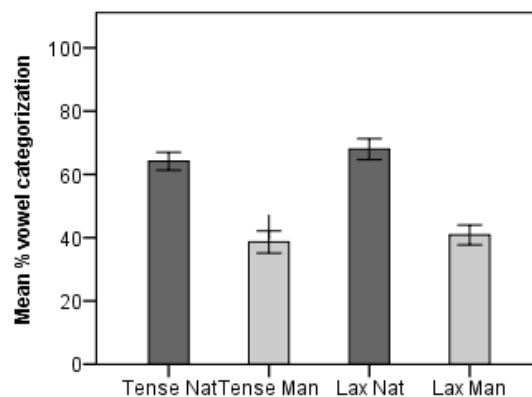


Fig. 1. Mean % of vowel categorization for natural and manipulated stimuli

Partial correlations controlling for L2 vocabulary size, were significant between SNWR (PSTM) scores and % of correct categorization of natural (but not duration-manipulated) stimuli (see Table 3).

Table 3. Correlations between categorization and SNWR scores (% correct).

Stimulus	Mean (SD) (N=31)	Correlations
Natural i:	64.16 (15.90)	.386 (p=.018)
Natural ɪ	67.97 (18.64)	.334 (p=.036)
Manipulated i:	38.62 (19.37)	.203 (p=.141)
Natural ɪ	40.86 (17.32)	.291 (p=.059)
SNWR	62.23 (13.93)	
X/Y-LEX	6141.94 (1231.47)	

Categorization accuracy scores were submitted to a repeated measures ANOVA with *stimulus type* (natural vs. manipulated) and *vowel type* (/i:/ vs. /ɪ/) as within-subjects factors. These analyses revealed a significant main effect of *stimulus type* ($F(1,30)=89.30$; $p<.001$). Neither *vowel type* ($F(1,30)=1.70$; $p=.203$), nor *stimulus type* x *vowel type* interaction ($F(1,30)=4.37$; $p=.514$) reached significance. This indicates that the participants used duration as a cue in categorization similarly for both vowels, so the scores for /i:/ and /ɪ/ were collapsed in subsequent analyses. We next assessed the role of PSTM dividing learners into high and low PSTM groups through a median split. *High PSTM* participants outperformed *Low PSTM* participants in all conditions (see Table 4 and Figure 2).

Table 4. *High* vs. *Low* PSTM mean vowel categorization scores (% correct).

Stimulus	<i>High</i> PSTM (N=16) Mean (SD)	<i>Low</i> PSTM (N=15) Mean (SD)
Natural i:	67.19 (16.64)	60.93 (14.93)
Natural ɪ	71.26 (17.47)	64.44 (19.74)
Manipulated i:	42.01 (22.84)	35.00 (14.76)
Natural ɪ	44.27 (20.92)	37.22 (12.09)

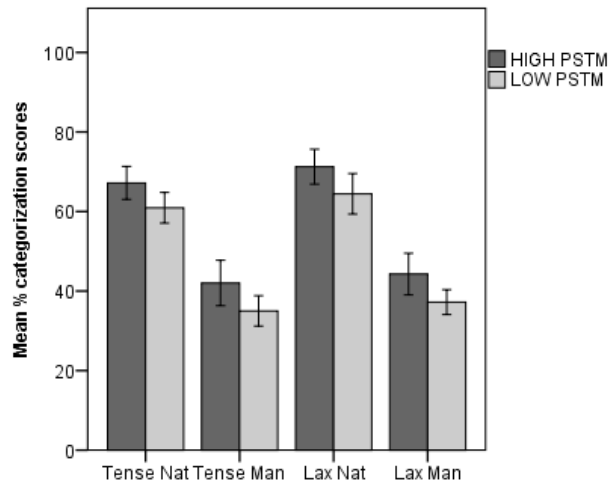


Fig. 2. PSTM and vowel categorization.

Categorization scores were submitted to mixed ANOVAs with *stimulus type* (natural vs. manipulated) as the within-subjects factor, *PSTM* (High vs. Low) as the between-subjects factor and the L2 vocabulary scores as a co-

variable. The main effect of *stimulus type* ($F(1,28)= 1.45; p=.238$), and the *stimulus type* x and *L2 vocabulary*, ($F(1,28)=.300; p=.588$), and *stimulus type* x *PSTM* ($F(1,28)=.000; p=.983$) interactions did not reach significance. However, the main effect of *PSTM* was significant ($F(1,28)= 4.90; p=.035$).

4. Conclusions

In line with previous research, the results of this study show that Spanish EFL learners over-rely on duration in the categorization of /i:-ɪ/. They obtained higher correct % categorization scores in natural than manipulated stimuli. PSTM was identified in this study as a significant factor affecting the categorization of /i:-ɪ/. The high PSTM group categorized both stimuli types (natural and manipulated) in a significantly more accurate way than the low PSTM group. Taken together, the outcome of this study indicates that further research looking into Spanish EFL learners' perception of English vowel contrasts should take into account PSTM as an important factor in L2 phonological acquisition.

Acknowledgments

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