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Vowel Inventory Size and the Use of Temporal Cues in Non-Native Vowel Perception by Catalan and Danish EFL Learners

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Abstract

This paper sought to determine whether L1 vowel inventory size could be a contributing factor to the use of temporal cues in L2 vowel perception. The participants were L1 Catalan (n=20) and L1 Danish (n=20) EFL learners and L1 English control group (n=7). We hypothesized that the smaller vowel inventory of Catalan could result in difficulties in discerning spectral differences and would lead to the over-use of temporal cues (Bohn, 1995). Cue-weighting was measured through natural and duration manipulated stimuli in a forced-choice word identification task.

Identification accuracy scores indicate that Catalans over-used duration and failed to discern /i-ɪ/ through spectral cues, whereas Danes resorted to duration as a primary cue to a lesser extent. We suggest that this might be due to differences in L1 vowel inventory size and, as a result, experience with small-scale spectral differences.)

The acquisition of second language (L2) vowels is a complex task. According to the current influential L2 speech learning models (Best, 1995;

Flege, 1995), the perceptual similitude between the first language (L1) and L2 vowels is one of the important predictors of how well the L2 speech sounds are acquired: more target-like acquisition is expected when the L2 speech sound is perceived as different to the existing L1 speech sounds.

In the temporal domain, speakers of quantity languages have been shown to acquire L2 vowel duration distinctions with ease (McAllister, Flege & Piske, 2002). On the other hand, speakers of languages without duration distinctions have been shown to face difficulties in acquiring vowels with contrastive duration (Nenonen, Shestakova, Huotilainen & Nääätänen, 2003; McAllister et al., 2002; Ylinen, Shestakova, Alku & Huotilainen, 2005).

In the acquisition of vowel quality, some researchers have suggested that speakers of languages with large vowel inventories have a benefit over speakers of languages with smaller vowel inventories (Fox, Flege & Munro, 1995; Frieda & Nozawa, 2007; Hacquard, Walter & Marantz, 2007; Iverson & Evans, 2007). This would be explained through the experience the L1 has offered to the speakers in tuning them to small-scale spectral differences, a task that should be more difficult for a speaker without such experience. It would thus seem that language learners can transfer their L1 cue-weighting strategies into the L2.

The aim of the current study was to determine whether the size of the L1 vowel inventory affects the use of perceptual cues used to discern between L2 vowels. We tested foreign language learners of English from two language backgrounds: Danish and Catalan. These languages differ not only in the number of vowels but also in the cues that are used to discern among them. We hypothesized that these differences could lead to different cue-weighting strategies. We selected the English /i-ɪ/ vowel pair to test our hypothesis. It is a very productive distinction in English (Higgins, 2013, distinguishes 466 minimal pairs) and thus important for foreign language learners to master. More importantly, it is of particular interest for Danish and Catalan speakers. Neither of the languages has a short lax vowel spectrally similar to English /ɪ/, but both have a tense vowel similar to English /i/. Thus it could be expected that perceiving and acquiring the distinction will pose some problems for L1 Catalan and L1 Danish EFL learners.

LITERATURE REVIEW

Native and Non-Native Cue-Weighting Strategies in /i-ɪ/

In Standard Southern British English (SSBE), which is the target dialect of our L2 participants and the native dialect of our L1 control group, the /i-ɪ/ vowel pair is distinguished by means of vowel quality and tenseness as well as quantity, i.e., everything else being equal, the tense vowel is longer than the lax vowel. Native speakers of American and British English have been shown to discern the /i-ɪ/ vowel pair based on spectral differences, making little use of temporal cues (e.g. Bohn & Flege, 1990). EFL learners from varying L1 backgrounds, on the other hand, have been shown to favor temporal cues over spectral cues (e.g. Bohn, 1995; Flege, Bohn & Jang, 1997; Ylinen et al., 2009). Researchers have offered various explanations to why non-native English speakers resort to the secondary temporal cues.

Some researchers have stated that EFL learners are often explicitly taught that the difference in /i-ɪ/ is that of duration: long-short (e.g. Flege et al., 1997). However, also L2 English speakers who have acquired the language in a naturalistic context, without explicit teaching of English phonetics and phonology, seem to rely on temporal cues. Thus a solely instruction-based explanation is not sufficient.

Negative transfer from the L1 cannot be accounted for as the only reason to why preference on duration cues occurs since speakers of both quantity languages (Finnish: Ylinen et al., 2009; Japanese: Morrison, 2002; Korean: Flege et al., 1997) and of languages that do not use duration contrastively (Mandarin: Bohn, 1995; Flege et al., 1997; Spanish: Escudero, 2006; Russian: Kondaurova & Francis, 2008) have been shown to rely on temporal cues.

Reliance on duration cues as a developmental stage has been proposed by Escudero (2000) and Morrison (2008). Both authors suggest that less proficient L2 learners are more inclined to rely on temporal cues and as language proficiency, and thus experience with the language, increases, cue-weighting becomes more English-like. It should be noted that both authors studied Spanish as the L1 and the developmental stages might not apply to speakers of other languages.

Escudero & Boersma (2004) suggested that the creation of duration distinction to the five existing L1 vowels is more economical for L1 Spanish speakers than acquiring the new English vowels based on spectral

differences. Their reasoning being, that it is easier to create new categories on a dimension that is not exploited in the L1 (duration) than to split existing L1 categories into several L2 categories. Although duration is not used contrastively in Spanish, it is not clear that duration is a blank slate in Spanish speakers' minds.

Kondaurova and Francis (2008) consider that L1 Russian and L1 Spanish speakers have experience with duration in their L1s through vowel lengthening before voiced consonants and in stressed syllables. They, as well as Morrison (2008), propose that experience with allophonic vowel duration variation in the L1 could be an explanation to why EFL learners tend to overuse temporal cues.

Another proposal is forwarded by Bohn (1995) after he discovered that native Mandarin and native Spanish speakers relied heavily on duration cues in identifying the English /i-ɪ/ although neither of the languages uses duration contrastively. Bohn suggests that temporal cues are easily available even for speakers without experience with them. According to his prediction, whenever the listener lacks L1 experience with spectral differences, the non-native contrast will be distinguished by means of duration. In the present study we follow Bohn's hypothesis and believe that non-native EFL learners' use of duration cues cannot be solely contributed to L1 transfer, improper instruction or experience with allophonic duration variation, but more likely it is related to the L1 vowel inventory size and organization.

Catalan Vowels

Catalan is a Romanic language spoken in eastern and northeastern Spain, Andorra and at the border regions of France with Spain. The variety spoken in Barcelona, where our participants were tested, is classified as Eastern Catalan. Eastern Catalan has eight simple vowels (/i e ε u o ɔ a ə/), seven occurring in stressed positions and one schwa-like vowel occurring in unstressed positions. Duration is not used contrastively in Catalan. The high front vowel region of Catalan has only one high front vowel /i/. Cebrian (2006) carried out acoustic comparisons, cross-linguistic perceptual assimilation patterns and goodness-of-fit ratings with native English and Catalan speakers. His acoustic results indicate that English /i/ and Catalan /i/ are highly similar. This is corroborated by high perceptual assimilation scores and goodness-of-fit ratings by Catalan and English speakers. Acoustic comparison between English /i/ and Catalan vowels

show that spectrally /ɪ/ is closest to Catalan /e/. Cebrian's perception tests show that Catalan speakers tend to assimilate the English /i/ to the native Catalan /i/. The English /ɪ/ is more dissimilar and is assimilated to the Catalan /e/, /i/ or /ɛ/. We could thus conclude that whereas the English /i/ can be easily assimilated to Catalan /i/, the English /ɪ/ is a new vowel whose perception causes more problems. Additionally, Catalan speakers have been shown to discern the English /i-ɪ/ mainly based on temporal cues, making little use of spectral cues (Cebrian, 2006; Cerviño & Mora, 2009; Mora & Fullana, 2007). Their ineffective cue-weighting strategy is likely to cause problems in both natural and manipulated vowel perception.

Danish Vowels

Danish is a North Germanic language spoken in Denmark. Our participants were speakers of Eastern Jutland Danish. Danish has at least 20 stressed monophthongs (Steinlein, 2005) distinguished primarily by means of temporal differences and by little spectral differences. Danish vowels occur in long-short pairs, namely /i-i:, e-e:, ɛ-ɛ:, a-a:, u-u:, o-o:, ɔ-ɔ:, y-y:, ø-ø:, œ-œ:/. Having almost all the vowels located in the upper half of the acoustic vowel space, Danish has four high front vowels (/i/,/i:/) and (/y/,/y:/), which are distinguished mainly by means of duration. Steinlein (2002) carried out cross-linguistic acoustic measurements for vowels embedded in a /hVt/ context. The results reveal that the English /i/ and the Danish /e/ did not differ significantly in their formant frequency. Moreover, the results showed that Danish /i/ differs very little from the English tense high front vowel and therefore, according to Bohn and Caudery (2012), the use of Danish /i/ does not contribute much to a foreign accent while producing the English /i/.

Bohn and Steinlein (2003) asked Danish listeners to identify the 11 SBE monophthongs produced in three consonantal contexts /hVt/, /dVt/, /gVt/ using Danish response categories. The English high front vowel /i/ was identified highly consistently with Danish counterparts (97-99%), even though the considerably poor goodness ratings indicate that the Danish listeners were sensitive to the differences between the two languages. Regarding the English vowel /ɪ/, the same study shows that the most frequent counterpart in Danish is /e/ in the /hVt/ and /dVt/ contexts, but /i/ in the /gVt/ context, indicating that vowel assimilation can be dependent

on the phonetic context. We could thus conclude that whereas the English /i/ can be easily assimilated to the Danish counterpart due to its similarity, the English /ɪ/ may pose more problems to Danish speakers, as it has been shown to be identified either with Danish /e/ or /i/. Additionally, due to the fact that “the Danish vowel system is characterized by a densely packed upper position of the vowel space” (Bohn & Nielsen, 2009, p. 210), this may indicate that Danish speakers are experienced with distinguishing high front vowels, which may facilitate their perception of such sounds.

Research Question

We posed the following research question:

- Is the size of L1 vowel inventory associated to the use of temporal cues in the perception of English /i-ɪ/?

Our hypothesis follows Bohn’s (1995) Desensitization Hypothesis and recent neurolinguistic research, which suggest that inventory size may influence the perceived dissimilarity between vowels (Hacquard et al., 2007). Speakers of languages with larger vowel inventories have been suggested to expand their perceptual space to accommodate the large number of vowels and thus be able to perceive larger distances between vowels than speakers with smaller vowel inventories (Hacquard et al., 2007). We would thus expect the L1 Danish speakers to perceive the spectral distance between English /i/ and /ɪ/ better than the L1 Catalan speakers. Additionally, Following Bohn (1995), we hypothesize that the smaller vowel inventory of Catalan has desensitized the L1 Catalan speakers to the spectral differences between the English /i-ɪ/. Thus, L1 Catalan speakers are forced to attend to the secondary temporal cues, which in turn would result in non-native-like cue-weighting. The larger vowel inventory of Danish should sensitize the L1 Danish speakers to the spectral differences between the English /i-ɪ/ without the need to attend to temporal properties. However, Danish also uses duration contrastively. It is possible that L1 Danish speakers would employ negative transfer, preferring duration cues to spectral ones. Nevertheless, as native speakers of English attend mainly to spectral cues, it is more likely that spectral cues are more reliable to speakers who are able to discern fine-grained spectral differences.

METHODOLOGY

Participants

20 L1 Catalan, 20 L1 Danish and 7 L1 English participants were tested. The Catalan and Danish participants were first year English majors at the University of Barcelona and at Aarhus University, respectively. The L1 English participants were living in Barcelona at the time of the data collection. The characteristics of the participants can be seen in table 1.

Table 1. Characteristics of the participants.

	L1 English (n=7)	L1 Danish (n=20)	L1 Catalan (n=20)
Age	27.7 (4.6)	23.05 (3.54)	22.85 (4.9)
Sex	7 f	15 f, 5 m	12 f, 8m
Self-estimated daily use of L1 (%)	67.80 (13.81)	74.90 (14.05)	81.70 (13.79)
Self-estimated daily use of L2 (%)	29.29 (13.36)	24.75 (13.90)	17.75 (14.27)

Since Barcelona is a bilingual city, the L1 Catalan participants also spoke Spanish. However, all the L1 Catalan participants were dominant in Catalan and reported to use more Catalan than Spanish. Only participants' own estimations of language proficiency and use were obtained. All the L1 Danish speakers considered themselves fluent in English, whereas 80% of the L1 Catalan speakers did so. Overall the L1 Danish speakers were perceived as more proficient in L2 English than the L1 Catalan speakers.

Instrument

Cue-weighting strategies were tested with a /i-ɪ/ word identification task consisting of natural and duration manipulated stimuli (Moya-Galé, 2010). Six CVC /i-ɪ/ minimal pairs (*bead-bid*, *beat-bit*, *deed-did*, *peak-pick*, *Pete-pit*, *seed-Sid*) spoken by six native SSBE speakers (three male, three female) were selected. Half of the items were natural and half of them were duration manipulated so that the tense and the lax vowel durations were interchanged (/i/ received the mean duration [155ms] of /ɪ/ and /ɪ/ received the mean duration [189ms] of /i/). As a result of the duration manipulation, the duration manipulated stimuli sounded synthetic, albeit

perfectly recognizable. In total there were 144 target items. The items were presented in a randomized order through computer software.

Procedure

L1 Catalan and L1 English participants were tested at the University of Barcelona and the L1 Danish participants were tested at Aarhus University. All the participants were tested individually in a quiet room. After filling in a language background questionnaire, the participants had a short familiarization session with the test words, after which they performed the identification task. In the word identification task, the participants were told to answer as fast and as accurately as possible and guess if needed. They were also informed that some of the items might not sound very natural and that they should try to ignore this variation. The overall duration of the testing session was approximately 30 minutes.

RESULTS

Participants' responses were analyzed and the percentage of correct responses for each condition (vowel/stimulus type) was calculated. Descriptive statistics are seen in table 2. Kolmogorov-Smirnov indicated that the L1 English and L1 Danish scores were not normally distributed, which is why non-parametric statistics were used in all further analyses.

Table 2. Percentage of correct identification. Standard deviations in brackets.

	L1 English	L1 Danish	L1 Catalan
ID natural	99.20 (1.57)	97.50 (4.21)	77.56 (12.16)
ID manipulated	98.01 (2.09)	94.16 (7.48)	51.31 (20.54)
Total ID	98.61 (1.65)	95.83 (5.62)	64.44 (15.74)
ID /ɪ/ natural	99.60 (1.04)	97.50 (4.40)	74.58 (15.79)
ID /ɪ/ manipulated	99.60 (1.04)	95.83 (7.00)	49.30 (19.68)
ID /i/ natural	98.80 (2.18)	97.50 (5.00)	80.55 (12.77)
ID /i/ manipulated	96.42 (4.15)	92.50 (8.60)	53.33 (23.92)

Table 3. Within-group differences

	L1 English	L1 Danish	L1 Catalan
ID natural	Z=-1.633	Z=-2,820;	Z=-3,922
ID manipulated	p=.102	p<.005*	p<.0005*

ID /i/ natural	Z=-1,342	Z=-.367;	Z=-1,564
-	p=.180	p=.714	p=.118
ID /ɪ/ natural			
ID /i/ manipulated	Z=-1,633	Z=-2,782	Z=-1,047
-	p=.102	p<.005*	p=.295
ID /ɪ/ manipulated			

Identification accuracy scores were submitted to a Wilcoxon Signed Ranks test (table 3) to explore within-group differences. Significant differences were found in the identification of the natural and duration manipulated stimuli in L1 Danish and L1 Catalan, but not in L1 English participants. This indicates that both, Catalan and Danish speakers relied on temporal cues, at least to some extent. The L1 English speakers, on the other hand, showed no effect of duration manipulation, which aligns with previous research indicating that native English speakers discern the /i-ɪ/ vowel pair mainly through spectral differences. Reliance on temporal cues appears to be the main strategy especially for the L1 Catalan speakers, whose identification accuracy dropped to chance level (51.31%) in the manipulated stimuli.

In natural trials, no differences were found in the identification accuracy between the two vowels. However, in the manipulated trials, L1 Danish participants identified the lax vowel significantly better than the tense vowel. Native speakers of English showed the same trend, although the difference was not significant. The L1 Catalan speakers showed a contrary trend: their identification of the manipulated tense vowel was better than of the manipulated lax vowel. However, the L1 Catalan identification accuracy scores in manipulated trials were at chance level in both vowels. There are several possible explanations to why L1 Danish and L1 English participants identified the manipulated lax vowel better than the tense vowel. On the one hand, whereas vowel tenseness is related to length, laxness is not necessarily related to shortness. Thus, shortening the tense vowel could have confused the L1 Danish and L1 English participants and resulted in lower identification accuracy in the manipulated tense trials. On the other hand, the longer the speech signal is, the more time the listener has to process it. Thus in the manipulated lax vowel trials, the listeners had more time to process spectral information than in the manipulated tense vowel trials. This extra processing time could have been beneficial for participants who rely on spectral cues. Finally, the reason could be found in the manipulation process: shortening

the tense vowel could have resulted in more artificial stimuli than lengthening the lax vowel.

Differences between groups (table 4) were explored with a Kruskal-Wallis Test with L1 as the independent factor and identification accuracy scores as the dependent factor. Kruskal-Wallis yielded significant differences in all test areas. Post-hoc Mann-Whitney comparisons further revealed that the L1 Catalan speakers significantly differed from the L1 Danish and L1 English speakers, but no statistical differences were found between the L1 English and L1 Danish speakers (figure 1).

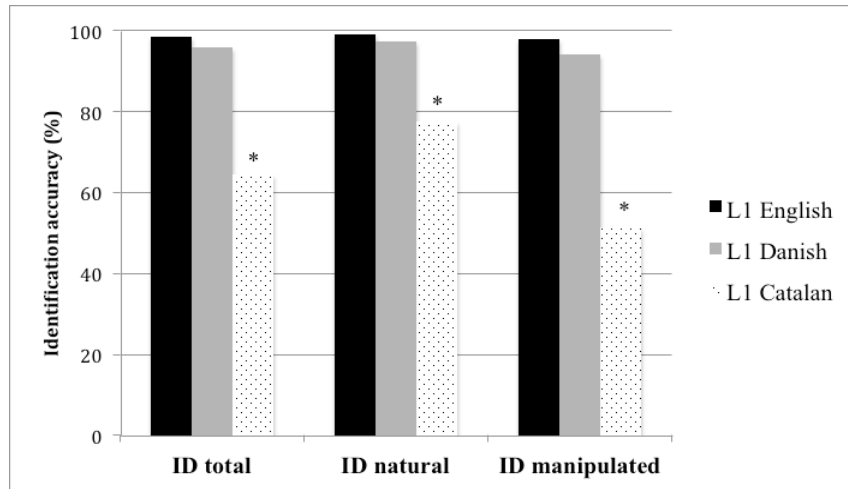


Figure 1. Between-group differences.

The L1 Danish and L1 Catalan speakers’ identification accuracy in the natural trials (97.50% cf. 77.56%) was significantly different. This could be an indication that the L1 Danish speakers were more proficient in English than the L1 Catalan speakers. As no formal proficiency tests were administered, this cannot be confirmed. However, the interaction with the participants in the testing situation suggested that the L1 Danish speakers’ English proficiency was in fact higher.

Table 4. Between-group differences.

	Kruskal-Wallis	Mann-Whitney Danish-Catalan	Mann-Whitney Danish-English	Mann-Whitney Catalan-English
Total ID	$\chi^2(2)= 30.43$; $p<.001^*$	$U(18)= -4.92$; $p<.001^*$	$U(38)=-1.78$; $p=.081$	$U(1)=-3.79$; $p<.001^*$
ID manipulated	$\chi^2(2)=29.39$; $p<.001^*$	$U(21)= -4.85$; $p<.001^*$	$U(45)=-1.40$; $p=.179$	$U(1)= -3.79$; $p<.001^*$

ID natural	$\chi^2(2)= 30.63;$ $p<.001*$	$U(18)= -4.95;$ $p<.001*$	$U(46)=-1.40;$ $p=.198$	$U(1)=-3.80;$ $p<.001*$
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In the duration manipulated trials, the L1 Danish speakers performance was native English-like. The L1 Catalan speakers' identification accuracy in all conditions (natural/manipulated/combined) was significantly poorer. The fact that L1 Danish and L1 Catalan speakers differed so radically from each other could be explained through our initial hypothesis: the denser (especially, the high front) vowel space of Danish has attuned L1 Danish speakers to small spectral differences, whereas the 8-vowel system of Catalan has not offered L1 Catalan speakers with enough experience on small-scale spectral differences. This would force them to resort to secondary temporal cues. Despite their native-English-like behavior, the L1 Danish speakers did identify the natural trials better than the duration manipulated trials ($p<.005$), showing that some reliance on temporal cues was taking place. We could thus conclude that the L1 English speakers were identifying the /i-I/ vowel pair mainly based on spectral cues, the L1 Catalan speakers discerned the vowels mainly based on temporal cues, whereas the L1 Danish speakers seem to have used a combination of both cues, favoring the spectral cues over the temporal ones (figure 2).

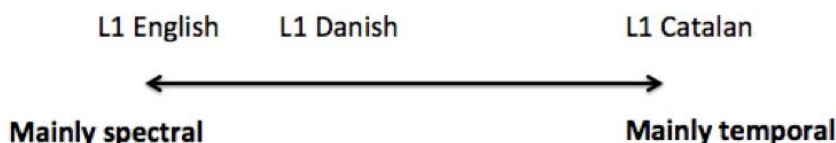


Figure 2. Cue-weighting strategies used by the different language groups.

DISCUSSION AND CONCLUSIONS

This paper examined the cue-weighting strategies of L1 Danish and L1 Catalan EFL learners when discerning the English /i-I/ vowel pair. We hypothesized that L1 Danish speakers would resort to spectral cues and L1 Catalan speakers would resort to temporal cues, as previous research with L1 Catalan speakers suggests. We suggest that these differences in the use of cue-weighting strategies are due to the L1 vowel inventory size. Namely, that experience in the L1 with fine-grained spectral differences sensitizes the L1 Danish speakers to perceive small spectral differences also in L2 English. The Danish high front vowel space is especially

crowded (having approximately 10 vowels) in comparison to the English high front vowel space (having 2 vowels). Catalan, on the other hand, has not provided the L1 Catalan speakers with enough experience with small-scale spectral differences; Catalan has eight vowels and only one high front vowel. As our results suggest, L1 Catalan speakers rely heavily on temporal cues, whereas the presence of spectral cues solely is not a sufficient condition for correct identification.

Our results offer preliminary support to Bohn's Desensitization Hypothesis (1995): the less crowded vowel space of Catalan desensitizes L1 Catalan speakers to small spectral differences of English, forcing them to resort to secondary temporal cues. On the other hand, the large vowel inventory of Danish has sensitized the L1 Danish speakers to perceive small spectral differences, a strategy that is successfully transferred into the L2. Our results show that whereas the L1 Danish speakers approximated to native English speakers, they still show a small effect of duration manipulation. We suggest that this might be due to the presence of contrastive duration in L1 Danish: the Danish vowels are grouped into short-long pairs, which differ only in duration (e.g. /y:/-/y/). From our results it seems that L1 Danish speakers also make use of their L1 contrastive duration when identifying the English /i-ɪ/. However, this appears to be a secondary strategy.

An alternative explanation to our results can be found from Escudero's (2000) proposal. She suggests that L1 Spanish learners of English go through developmental stages in the acquisition of the /i-ɪ/ contrast. The first developmental stage is distinction through temporal cues, which is followed by stage 2, the use of mainly duration but also spectral cues and stage 3, the use of mainly spectral but also duration cues. The final stage consists of native English-like perception through the combination of spectral and duration cues, favoring the spectral ones. Morrison (2008) included an additional preliminary stage in which the English /i-ɪ/ are assimilated to Spanish /i/ as either good or bad matches. If the L1 Danish speakers had higher English proficiency than the L1 Catalan speakers, we could find an alternative explanation from these theories. It could be that the L1 Catalan speakers were in the initial stages (1-2) and the L1 Danish speakers were in further developmental stages (3-4). Since L2 proficiency was not objectively tested in this study, we cannot exclude the effect of language proficiency on the cue-weighting strategies. However, similar results to ours have been found when more proficient L1 Catalan learners

of English have been tested (Cebrian, 2006). This would indicate that there is more to the matter than language proficiency.

Our study has examined EFL learners in two languages with differing L1 vowel inventory sizes and offered preliminary support to Bohn's (1995) Desensitization Hypothesis. Previous studies suggest (e.g. Ylinen et al., 2009) that it is possible to shift language learners' attention to weight more relevant cues. We believe that L1 Catalan learners would benefit from perceptual cue-training with duration manipulated stimuli in order to obtain a more native English-like perception of the /i-ɪ/ vowel pair. Future research on the relation of the L1 vowel inventory size and cue-weighting strategies should be expanded to more languages. Testing speakers of languages with varying vowel inventory sizes is the only way to determine the role of L1 vowel inventory size in L2 vowel perception.

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