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Catalan speakers' perceptual assimilation of English vowels:

Effects of L2 experience and phonetic context

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ABSTRACT

This research project investigated the role of L2 experience and phonetic context in Catalan speakers' perceptual assimilation of English vowels. A Perceptual Assimilation Task was performed by L2 learners and non-learners in which they had to assimilate the English vowels /iː, ɪ, ɛ, æ, ʊ, uː/ to a Catalan vowel category and provide goodness-of-fit ratings. Results for English /i/, /æ/, /u/ showed that highly assimilated vowels are not affected by context or L2 experience. English vowels /ʊ/, /ɪ/ and /ɛ/, which had no clear mapping to any Catalan categories, showed some consonantal and experience effects, especially for inexperienced learners. However, the little difference in the results between the proficiency levels and the contexts is a possible indicator that these two factors do not influence cross-linguistic perceptual assimilation.

1. INTRODUCTION

The following study investigated the effect of consonantal context on the perceptual assimilation of British English vowels by two groups of native Catalan listeners that differed in amount of English proficiency. The results will be used to acquire a better understanding of the relationship between first language (L1) and second language (L2) sound systems that will help to improve our understanding of the process of second language acquisition.

1.1. Importance of cross-linguistic similarity for speech models

Current models of nonnative speech perception assume that ease of acquisition of nonnative (L2) sounds can be predicted on the basis of their perceived phonetic similarity to native (L1) sounds (Best, 1994; Flege, 1995). That is, the more similar an L1 and L2 sounds are, the more difficult they will be to discriminate. These models are the Speech Learning Model (Flege, 1995) and the Perceptual Assimilation Model (Best, 1995; Best & Tyler, 2007).

The Speech Learning Model (SLM) focuses on learners' difficulty to acquire L2 phonemes, which is linked to production accuracy. This model suggests that this difficulty depends on the similarity between an L2 sound and its closest L1. Thus, the greater the phonetic distance between L1 and L2 sounds is, the more likely it is that L2 learners eventually form target-like L2 categories given sufficient experience with the target language.

The Perceptual Assimilation Model (PAM) focuses exclusively on nonnative perception by naïve listeners (without linking it to production). The PAM posits that the difficulty to perceive L1/L2 contrasts will depend on the extent to which L2 sounds are

assimilated to L1 sounds, and on their goodness of fit (grading from 'good' to 'poor') to L1 categories, which will predict accuracy in the discrimination of L1/L2 sounds.

Although the predictions of these models will not be specifically tested in this study, as that would imply testing discrimination between English vowels, the point of mentioning both models of L2 speech is to highlight the importance of cross-linguistic similarity. This is so because the models crucially base their predictions on the degree of similarity between native and nonnative sounds. Thus, a crucial first step for studies on L2 speech involves assessing the degree of similarity between L1 and L2 sounds.

1.2. Previous research on Catalan & English cross-linguistic similarity

Some previous studies have evaluated the perceptual similarity between Catalan and English vowels. For example, Cebrian (2006) investigated the way Catalan speakers and Canadian English speakers identified English /i, ɪ, ɛ, eɪ/ vowels and Catalan /i, e, ɛ, ei/ vowels in a /hVb/ context in terms of their native (L1) categories and provided goodness-of-fit ratings in a Perceptual Assimilation Task (PAT). The results showed that English /i, ɛ, eɪ/ were highly assimilated to, that is, identified as, Catalan /i, ɛ, ei/, but English /ɪ/ obtained lower assimilation scores as Catalan /e/.

Rallo Fabra (2005) tested the assimilation of American English vowels to Catalan vowels in a /sVt/ context by experienced and inexperienced listeners in a similar Cross-language Mapping Task (CMT), in which L2 categories have to be identified in terms of L1 categories. According to the results, English /i, u/ were highly assimilated to Catalan /i, u/, English /æ, ʌ, ɑ, ɔ/ were assimilated to a single Catalan vowel /a/, and English /ɪ, ɛ, ʊ/ were not found to assimilate consistently to a Catalan category. In the case of English /ɪ/, this was identified as Catalan /e/ by inexperienced

listeners but as Catalan /i/ and 'non-Catalan' by experienced learners, showing the effect of language experience on the degree of perceived similarity between native and nonnative vowels. By contrast, Cebrian (2009) tested the assimilation of Canadian English vowels to Catalan vowels in /bVs/ context by native Catalan speakers and Catalan learners of English by means of a PAT but no language experience effect was found. Results indicated high assimilation of Canadian English /i/ to Catalan /i/, assimilation of Canadian English /æ, ʌ/ to a single Catalan vowel /a/, assimilation of Canadian English /ʊ, u/ to Catalan /u/ and /ɪ, ɛ/ were not found to assimilate consistently to a single Catalan category.

Cebrian, Mora and Aliaga-Garcia (2011) tested cross-linguistic perceived similarity between Catalan and Southern British English (SBE) in /bVt/ context by means of a PAT and a Rated Dissimilarity Task (RDT) in which listeners indicated the degree of dissimilarity between two vowel stimuli on a 7-point Likert scale. The results for the PAT showed that SBE /ɪ, æ, ɛ/ were highly assimilated to Catalan /i, a, ɛ/ , SBE /eɪ, u, əʊ, ɔ, ʌ, ɪ/ were also highly assimilated to Catalan /ei, u, ou, o, a, i/ but with lower goodness of fit and SBE /ɑ, ɒ/ showed moderate assimilation to Catalan /a, ɔ/ but moderate goodness of fit.

Finally, when testing perception of English vowels in a CMT, Rallo Fabra and Romero (2012) observed that English /e, æ, ɛ, ɑ, i, u/ were highly assimilated to Catalan /ɛ, a, i, u/. The only exception was found for English /ɪ/ with a low assimilation to Catalan /i/.

A comparison across the different studies illustrates that there are some similarities as well as some discrepancies in the results regarding the patterns of assimilation of some English vowels to Catalan categories. For instance, English /ɪ/ was assimilated to Catalan /i/ (Rallo Fabra, 2005; Cebrian, 2009; Cebrian, Mora & Aliaga-

Garcia, 2011) or as Catalan /e/ (Cebrian, 2006) with varying degrees of consistency across studies. These differences in the results may be due to the fact that different stimuli types involving different consonantal contexts were used, and that studies might differ in the level of L2 proficiency of the participants. Therefore, this study wants to go a step further by exploring both the effect of context, including different consonantal contexts, and the effect of experience, by testing two proficiency groups.

1.3. Consonantal context effect on perception

Vowels are mostly produced in consonantal context so they do not usually reach their canonical target values in natural speech (Steven & House, 1963). For that reason, testing the perceptual similarity of native and nonnative vowels in isolation is inadequate to provide answers on cross-language speech perception (Best, 1994; Flege, 1995; Strange, Bohn, Trent, McNair & Bielec, 1996; Strange, Akahane-Yamada, Fitzgerald & Kubo, 1998). Then, it follows that cross-linguistic similarity of vowel sounds should be presented in consonantal context for more accurate testing.

In addition, it has to be taken into account that coarticulatory (i.e. allophonic) variations of vowels occur in consonantal contact. That is, vowels may be affected by the adjacent consonants, which might lead to perceptual variation of vowel sounds. Hence, generalizations cannot be made beyond the context in which vowels are analyzed (Strange, Akahane-Yamada, Kubo, Trent & Nishi, 2001). Furthermore, "differences in articulation (and consequently, in acoustic formation) and in phonological structure might lead to differences in how native speakers may perceive vowels in the two languages", (Gottfried, 1984: 92). That is, the perceived similarity of L1 and L2 sounds might also be influenced by the knowledge about L1 variation in context, as some studies suggest (Strange et al., 1996; Bohn & Steinlen, 2003, Levy &

Strange, 2008). Therefore, in order to decide the phonetic context in which vowels are to be presented, the effect of consonantal context on vowel articulation in Catalan and in English will be reviewed.

Coarticulatory variation in English has been analyzed in different studies. For instance, Hillenbrand and Clark (2001) examined the effects of both place of articulation and voicing. According to the study, place of articulation has the following effects: /u/ shows the highest context variability with F2 values being higher (i.e. vowel is more fronted) in alveolar context. F2 values are also higher for the rest of back vowels (especially for /ʊ/) in alveolar context, and in velar context (to a lesser extent). In the case of front vowels, they have lower F2 in labial context. F1 values (i.e. vowel height) are higher in alveolar and velar contexts for /ɛ, æ/ vowels, meaning that vowels are lower. The results from the acoustic analysis (Hillenbrand & Clark, 2001) revealed that place of articulation has a greater effect in initial than in final position in the syllable. This study examined the effect of the consonants' place of articulation, but not the effect of syllable position, and thus vowels will be preceded and followed by the same consonant. On the other hand, differences in consonant voicing will be included, as voicing also seems to affect the production of vowels in English. F1 values of back and central vowels are somewhat lower (i.e. the vowel is higher) in the environment of voiced consonants (Hillenbrand & Clark, 2001).

Several studies by Recasens and colleagues have examined the effect of consonant place of articulation on vowel coarticulatory variation in Catalan (Recasens, 1985, 1990; Recasens & Espinosa, 2006). According to these studies, /i/ shows the highest degree of variability resistance, as Stevens and House (1963) claimed for American English. On the other hand, /u/ also shows the largest degree of variability, with F2 values being higher in dento-alveolar context. F2 values for /a/ are higher in

alveolar and velar contexts than in labial context. In general, there is greater F2 variability for back vowels in dento-alveolar context than for front vowels. Findings from both groups of studies seem to suggest that Catalan and English vowels are influenced by consonantal context.

Due to the differences in their vowel inventories and the transfer of native expectations about vowel coarticulation, the assimilation of nonnative sounds might vary depending on the context, even to the point that a nonnative sound is assimilated to a different native sound depending on the consonantal context. This was the outcome in a study by Bohn & Steinlen (2003), who found out that English /ɪ/ was perceived as being closer to Danish /i:/ in velar context but closer to Danish /e/ in glottal and alveolar contexts. Similarly, Cebrian (2014) found that Chilean Spanish speakers perceived Southern British English /u/ preceding a coronal stop mostly as Spanish /i/.

Nevertheless, provided that producing and perceiving coarticulatory variation in an L2 is part of the learning process, then it follows that L2 experience might reorient perception of L2 segments in a more native-like manner (Rallo Fabra, 2005; Levy, 2009). In a CMT task, Rallo Fabra (2005) tested Catalan listeners with and without English experience. On average, the experienced group selected the 'non-Catalan' response more often than the inexperienced group, suggesting that learning an L2 increases learners' ability to discern differences between English and Catalan vowel sounds. Levy (2009) also provided evidence that more experienced American learners of French made fewer errors in assimilation tasks.

Previous studies have shown that consonantal contexts and language experience have effects on cross-language perceptual assimilation, causing consistency differences in assimilation patterns of vowels, or even differences in the classification of the same

vowel sound (Bohn & Steinlen, 2003; Levy & Strange, 2008; Levy, 2009). Furthermore, both consonantal context and language experience effects were tested and found to affect the perceptual assimilation of French vowels by American learners (Levy & Strange, 2008; Levy, 2009). In Levy's research (2009), assimilation patterns for French vowels were more consistent in bilabial that in alveolar contexts, and the experienced group was generally more consistent in their mapping of French vowels than the inexperienced group. However, there is a lack of research on cross-language perceptual assimilation by Catalan speakers testing the effects of both consonantal context and L2 experience in the same study.

1.4. The present study

The purpose of this research project is to expand previous studies involving cross-linguistic similarity between Catalan and English vowels by exploring the effects of consonantal context and amount of L2 experience on cross-language vowel perceived assimilation by native Catalan speakers. This study thus aims at answering the following research questions:

(1) Does cross-linguistic perceived assimilation of English vowels in consonantal context vary as a function of L2 experience? To what extent?

Differences in assimilation of English vowels between native Catalan speakers of different levels of proficiency in English are difficult to predict since, while some previous studies have reported language experience effects (Rallo Fabra, 2005), others have not (Cebrian, 2009). However, our hypothesis is that, whatever the degree of variability as a function of L2 proficiency is, the experienced group will be more consistent in their mapping of English vowels following Levy (2009).

(2) Does perceptual assimilation of English vowels by native Catalan speakers vary as a function of consonantal context? To what extent?

According to research on coarticulatory variation in English (Hillenbrand & Clark, 2001) and in Catalan (Recasens, 1985, 1990; Recasens & Espinosa, 2006), patterns of coarticulatory variation are similar in both languages. Thus, our hypothesis is that native Catalan speakers' assimilation might be affected by context in the cases were the participants cannot find a clear L1 match from the L2 stimulus they receive. If they do not know coarticulatory variation of the vowel sounds, they will assimilate vowels differently depending on the context and that they will be reflected in their results. However, as Rallo Fabra (2005) and Levy (2009) point out, part of the learning process means producing and perceiving coarticulatory variation in an L2. Therefore, if learners know how English vowels vary with context, then they will be more consistent with their responses in a perceptual assimilation task.

2. METHODOLOGY
2.1. Stimuli

Two female native speakers of British English (a Southern British English speaker and a Northern British English speaker) were recorded producing the English vowels /iː, ɪ, ɛ, æ, ʊ, uː/ in 6 stop consonantal contexts /pVp, bVb, tVt, dVd, kVk, gVg/ in the carrier sentence "It rhymes with_____. I say haCVC. I say haCVC again" (or "It contains the vowel in_____. I say haCVC. I say haCVC again", in the cases where there was no rhyming word). For example, to elicit vowel /æ/ in a voiceless bilabial environment, the carrier sentence was "It rhymes with gap. I say hapap. I say hapap again".

English /iː, ɪ, ɛ, æ, ʊ, uː/ vowels were chosen due to the effect that consonantal context has on them as discussed above. Although front vowels show little consonantal context effect, they were added for comparison purposes, since the /i, ɪ/ contrast does not exist in Catalan. The consonantal context was limited to stops in order to focus exclusively on place of articulation as the main variable factor, as place of articulation has been shown to affect coarticulatory production and perception of vowels. Additional contexts such as nasal or fricative context were not included for the sake of simplicity and are left for future study. An unstressed neutral ha- prefix was added to all the words with the purpose of creating nonsense words, since some of the stressed syllables coincided with actual words. This was done in order to prevent word knowledge from interfering with the participants' responses.

Tokens were read by the two English native speakers from an elicitation list (see Appendix A). Speakers read the whole list twice and they were asked to repeat specific tokens when they were not produced naturally or correctly[1]. Recording sessions took place in a soundproof room at the Speech Laboratory of the Faculty of Philosophy and Arts in the Universitat Autònoma de Barcelona (UAB). After all the tokens were recorded, the nonsense words were extracted (a total of 72 tokens) and then normalized for intensity using Praat software (Boersma, 2014).

2.2. Participants

Twenty-three native Catalan speakers participated in the experiment (mean age of 21). They all agreed to participate in the experiment and they (native English speakers included) signed in a consent form (see Appendix C). Previous to the test, they

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[1] One of the speakers produced t-glottalization in final position so she was asked to produce final /t/ normally. In addition, both speakers had problems when producing /ʊ/ in /pVp, bVb, gVg/ contexts since these consonants do not appear in final position after /ʊ/ in English, so they were asked to repeat them again.

filled in a questionnaire (see Appendix B) about their language background, including information of their first language (they were required to have Catalan as their first language), and their English proficiency. Most of the participants spoke Central Catalan and were from the Barcelona metropolitan area. The participants were divided into two groups that varied in degree of English proficiency in order to test the possible effects of L2 experience on the assimilation of nonnative vowels. The experienced group was formed by 12 third and fourth-year students of English Studies at the UAB. Their actual proficiency was not tested but all of them had completed two terms of an English Phonetics and Phonology course, which included perception and production practice, the study of the English sound system and phonetic transcription. The inexperienced group was initially formed by 11 students of different degrees; the data from one participant had to be discarded[2]. Nowadays, it is difficult to find young participants with no English experience at all, since English is taught in high school and people are more exposed to English in a globalizing world due to the use of internet. Although their proficiency level was not tested before the experiment, all the inexperienced participants reported having little knowledge of English.

2.3. Task and procedure

After all the stimuli were ready (36 tokens x 2 speakers x 2 times = 144 stimuli), they were randomly sequenced and presented (using Praat) to the participants of both proficiency groups. Participants were tested individually for 30 minutes in a quite computer room at the Speech Laboratory. The test consisted of a Perceptual Assimilation Task (PAT). Participants listened to the stimuli through 'Sennheiser HD 218' headphones and had to choose (by clicking) one option out of the seven that

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[2] The responses of one of the participants seemed to be random so his results were excluded.

appeared on the computer screen. The seven options represented the Catalan vowels that can appear in stressed position and an example of each, that is, 'i (si)', 'é (sé)', 'è (fe)', 'a (sa)', 'ò (so)', 'ó (no)' and 'u (nu)'. (/i/, /e/, /ɛ/, /a/, /ɔ/, /o/ and /u/, respectively). In each trial, the stimulus was heard once with the option to repeat it one more time (by clicking) if necessary. After selecting the Catalan response with the highest similarity to the English stimulus, participants had to rate the vowel according to its degree of similarity to the selected Catalan vowel on a 7-point scale ('1' corresponded to very low similarity and '7' corresponded to very high similarity to the English vowel).

A practice test with only 12 stimuli was used before the real test to help participants to familiarize with the task, so their initial responses were not taken into account for analysis. When the actual test began, the participants could take a one-minute break every 48 stimuli (three breaks). After they finished the experiment, results were extracted for their analysis.

3. RESULTS

3.1. Main patterns of assimilation

Before analyzing the data, participants responses were divided in two proficiency groups according to their English proficiency level (experienced and inexperienced). For each group, the number of times each English vowel was identified as a given Catalan vowel was summed and the percentage of that Catalan response was calculated out of the rest of Catalan responses for a single English vowel. For each case, the average goodness-of-fit rating was calculated. Standard deviation was calculated as well, by estimating the standard amount of distance from the average goodness ratings. (see Appendix D for the confusion matrices presenting the full set of responses and results).

Table 1 presents the most common patterns of assimilation of the six English vowels in terms of the Catalan vowel categories and their corresponding goodness of fit ratings. The standard deviations of the goodness ratings ranged from 1 to 1.7, indicating that participants were generally consistent with all their responses. The English vowels /i/, /æ/ and /u/ were assimilated with the highest scores, being identified as Catalan /i/, /a/ and /u/, respectively, more than 85% of the time with a goodness-of-fit rating of 5.1 out of 7 or higher. English /ʊ/ was identified with relatively high assimilation scores (63-67%) but lower goodness of fit ratings (3.9-4.9) as Catalan /u/. The English vowel /ɪ/ was perceived with lower assimilation scores as Catalan /i/ (42-63%) but similar goodness of fit ratings (4-5), and to a lesser extent as Catalan /e/ with lower assimilation scores (27-32%) and lower goodness ratings (4-4.3). English /ɛ/ had no clear mapping to Catalan vowels, which assimilated to Catalan /a/ (60%, goodness rating: 4.6) and to Catalan /ɛ/ (17%, goodness rating: 4) by the inexperienced group, but to Catalan /ɛ/ (48%, goodness rating: 5.1) and to Catalan /a/ (39%, goodness rating: 3.8) by the experienced group.

Table 1. Mean percent assimilation of English vowels to Catalan vowels and mean goodness ratings for the two proficiency groups. Goodness ratings are given in parentheses.

Catalan responses	British English stimuli					
	Eng /i/	Eng /ɪ/	Eng /ɛ/	Eng /æ/	Eng /ʊ/	Eng /u/
Less experienced	as Cat /i/ 99% (5.7)	as Cat /i/ 42% (5) as Cat /e/ 32% (4.3)	as Cat /a/ 60% (4.6) as Cat /ɛ/ 17% (4)	as Cat /a/ 85% (5.2)	as Cat /u/ 67% (4.9) as Cat /ɔ/ 11% (4.6) as Cat /o/ 11% (4.3)	as Cat /u/ 94% (5.2)
More experienced	as Cat /i/ 100% (5.9)	as Cat /i/ 63% (4) as Cat /e/ 27% (4)	as Cat /ɛ/ 48% (5.1) as Cat /a/ 39% (3.8)	as Cat /a/ 94% (5.4)	as Cat /u/ 63% (3.9) as Cat /o/ 13% (4.3)	as Cat /u/ 98% (5.1)

3.2. Proficiency results

Results for the two different levels of proficiency are also presented in Table 1. As it can be seen, there is mostly little variation between the two groups in terms of their modal responses. English /i/ was the vowel assimilated with the highest score to Catalan /i/ for both groups, with 99% of assimilation and 5.7 of goodness of fit by the inexperienced group, and 100% of assimilation and 5.9 of goodness of fit by the experienced group. No big differences were found between the two groups with English /u/, which was highly assimilated to Catalan /u/ by the inexperienced group (94%) and by the experienced group (98%) with high goodness of fit ratings of 5.2 and 5.1, respectively. Similarly, the English vowel /æ/ was consistently identified as the Catalan vowel /a/ by both groups, with assimilation percentages of 85% and 94% and goodness ratings of 5.2 and 5.4, obtained by the inexperienced group and the experienced group respectively. English /ʊ/ was assimilated with lower but still a similar score to Catalan /u/ by the inexperienced group (67%) and the experienced group (63%) with moderate goodness ratings of 4.9 and 3.9, respectively. Regarding English /ɪ/, the inexperienced group showed no consistent results as this English vowel was perceived mostly as either Catalan /i/ (42%, with a mean goodness rating of 5) or Catalan /e/ (32%, goodness rating: 4.3). For the experienced group, there was a greater tendency to identify English /ɪ/ as Catalan /i/ (63%, goodness rating: 4) than as Catalan /e/ (27%, goodness rating: 4). Interestingly, there was a difference between the two groups regarding the English /ɛ/. Whereas the inexperienced group perceived it more times as Catalan /a/ (60%, goodness rating: 4.6) than as Catalan /ɛ/ (17%, goodness rating: 4), the experienced group perceived it more times as Catalan /ɛ/ (48%, goodness rating: 5.1) than as Catalan /a/ (39%, goodness rating: 3.8).

3.3. Voicing results

The results in Table 2, which presents the assimilation results separately for voiced and voiceless contexts, seem to indicate little voicing effect in most of the responses. For the English vowels /i/, /u/ and /æ/, the results obtained in the voiced and voiceless contexts were very similar. They were identified as Catalan /i/, /u/ and /a/, respectively, with high assimilation scores and high goodness ratings. As mentioned in the previous section, English /ɛ/ was identified as more similar to Catalan /a/ by the unexperienced group and as more similar to Catalan /ɛ/ by the experienced group. However, voicing did not seem to play a role in the assimilation patterns since the choice of Catalan /a/ by the inexperienced group (58-62%, goodness rating: 4.6) and of Catalan /ɛ/ by the inexperienced group (44-52%, goodness rating: 5-5.2) did not seem to depend on whether the English vowel was found in a voiced or voiceless context.

Table 2. Mean percent assimilation percentages and goodness ratings for the six English vowels in voiced and voiceless contexts

	British English stimuli					
Catalan responses	**Eng /i/**	**Eng /ɪ/**	**Eng /ɛ/**	**Eng /æ/**	**Eng /ʊ/**	**Eng /u/**
Voiced						
Less experienced	as Cat /i/ 99% (5.7)	as Cat /i/ 47% (5.2) as Cat /e/ 29% (4.1)	as Cat /a/ 58% (4.6) as Cat /ɛ/ 19% (4)	as Cat /a/ 88% (5.2)	as Cat /u/ 82% (5)	as Cat /u/ 96% (5.2)
More experienced	as Cat /i/ 100% (5.8)	as Cat /i/ 59% (3.9) as Cat /e/ 33% (4)	as Cat /ɛ/ 44% (5) as Cat /a/ 40% (3.6)	as Cat /a/ 94% (5.3)	as Cat /u/ 65% (4.1) as Cat /o/ 14% (3.1)	as Cat /u/ 98% (5.1)
Voiceless						
Less experienced	as Cat /i/ 98% (5.7)	as Cat /i/ 37% (4.8) as Cat /e/ 34% (4.4)	as Cat /a/ 62% (4.6) as Cat /ɛ/ 15% (4)	as Cat /a/ 82% (5.2)	as Cat /u/ 52% (4.8) as Cat /ɔ/ 17% (4.7) as Cat /o/ 16% (4.3)	as Cat /u/ 92% (5.1)
More experienced	as Cat /i/ 99% (6)	as Cat /i/ 67% (4.1) as Cat /e/ 20% (4)	as Cat /ɛ/ 52% (5.2) as Cat /a/ 38% (4.2)	as Cat /a/ 94% (5.5)	as Cat /u/ 61% (3.8) as Cat /o/ 11% (2.9)	as Cat /u/ 99% (5.2)

Interestingly, the pattern of Catalan responses for the English /ɪ/ may have been influenced by the voicing context depending on the proficiency group. In the inexperienced group, English /ɪ/ was assimilated more times to Catalan /i/, with higher assimilation scores and higher goodness ratings, in voiced context (47% and 5.2, respectively) than in voiceless context (37% and 4.8). By contrast, English /ɪ/ was assimilated more times to Catalan /i/ in voiceless context (67% and 4.1) than in voiced context (58% and 3.9). However, due the opposed tendency of the two contexts, depending on the proficiency group and the small difference between voiced and voiceless contexts, it could be assumed that voicing is not the cause of these different tendencies. English /ʊ/ was generally identified as Catalan /u/ obtaining similar assimilation scores and goodness ratings in both voiced and voiceless contexts by the experienced group. On the other hand, the inexperienced group's responses seemed to vary depending on whether the English vowel was surrounded by voiced or voiceless consonants. Catalan /u/ was still the main response in both contexts, but while in voiced context English /ʊ/ was highly assimilated to Catalan /u/ (82%) and received high goodness ratings (5), in voiceless context it was less consistently assimilated to Catalan /u/ (52%) and obtained moderate goodness ratings (4.8).

3.4. Place results

Table 3 presents the results for each consonant place of articulation separately, that is for labial, alveolar and velar contexts. As in previous sections, the identification of the English vowels /i/, /æ/ and /u/ did not seem to be affected by consonant context (place in this case). English /i/ was identified as Catalan /i/ with the highest assimilation scores (99-100%) and the highest goodness ratings (5.6-6.1) across all three places of articulation, followed by English /u/, which was identified as Catalan /u/ with high

assimilation scores (96-100%) and high goodness ratings (4.7-5.5), and English /æ/ as Catalan /a/ with lower assimilation scores (76-97%) but high goodness ratings (4.9-5.7). English /ɪ/ was assimilated differently by the two proficiency groups, but the responses followed the same tendency: assimilation scores and goodness ratings were higher in alveolar context. Thus, the experienced group identified English /ɪ/ as Catalan /i/ with moderate assimilation scores (55-58%) and moderate goodness ratings (3.6-3.8) in labial and velar contexts but they obtained higher assimilation scores (76%) and higher goodness ratings (4.5) in alveolar context. The inexperienced group identified English /ɪ/ as Catalan /e/ with moderate assimilation scores (38-39%) and moderate goodness ratings (4-4.4) in labial and velar contexts, but they identified it as Catalan /i/ with higher assimilation scores (63%) and higher goodness ratings (4.9) in alveolar context.

The responses for the English vowel /ɛ/ also differed with place of articulation when comparing the two proficiency groups. The inexperienced group identified English /ɛ/ as Catalan /a/ with moderate assimilation scores (46-69%) and moderate goodness ratings (4.3-4.8) in labial, alveolar and velar contexts. The experienced group identified English /ɛ/ as Catalan /ɛ/ with moderate assimilation scores (52-56%) and moderate goodness ratings (4.9-5) in alveolar and velar contexts, but they identified it as Catalan /a/ with moderate assimilation scores (51%) and moderate goodness ratings (3.9) in labial context. Finally, English /ʊ/ was generally identified as Catalan /u/ with higher assimilation scores (68-75%) and higher goodness ratings (3.9-5.4) in labial and velar contexts than in alveolar context, with lower assimilation scores (47-55%) and lower goodness ratings (3.5-4.4). Interestingly, the experienced group identified English /ʊ/ as Catalan /u/ in alveolar context with lower assimilation scores and lower goodness ratings (47% and 3.5, respectively) and also identified it as Catalan /i/ (20% and 2.7), which is a front vowel.

Table 3. Mean percent assimilation and goodness ratings for the six English vowels in labial and alveolar and velar contexts

	British English stimuli					
Catalan responses	Eng /i/	Eng /ɪ/	Eng /ɛ/	Eng /æ/	Eng /ʊ/	Eng /u/
Labial						
Less experienced	as Cat /i/ 99% (5.8)	as Cat /e/ 39% (4) as Cat /i/ 35% (5.1)	as Cat /a/ 65% (4.8) as Cat /ɛ/ 13% (4.3)	as Cat /a/ 76% (5.4)	as Cat /u/ 73% (5) as Cat /o/ 14% (4.9) as Cat /ɔ/ 10% (4.8)	as Cat /u/ 98% (5.5)
More experienced	as Cat /i/ 100% (5.8)	as Cat /i/ 58% (3.6) as Cat /e/ 30% (3.9)	as Cat /a/ 51% (3.9) as Cat /ɛ/ 36% (5.6)	as Cat /a/ 92% (5.1)	as Cat /u/ 68% (3.9) as Cat /o/ 18% (3.1)	as Cat /u/ 99% (5.5)
Alveolar						
Less experienced	as Cat /i/ 99% (5.6)	as Cat /i/ 63% (4.9) as Cat /e/ 19% (4.7)	as Cat /a/ 69% (4.6) as Cat /ɛ/ 11% (3.9)	as Cat /a/ 90% (4.9)	as Cat /u/ 55% (4.4) as Cat /o/ 11% (3.6) as Cat /ɔ/ 10% (4.5)	as Cat /u/ 89% (4.8)
More experienced	as Cat /i/ 100% (6.1)	as Cat /i/ 76% (4.5) as Cat /e/ 22% (4.1)	as Cat /ɛ/ 52% (4.9) as Cat /a/ 42% (4)	as Cat /a/ 97% (5.4)	as Cat /u/ 47% (3.5) as Cat /i/ 20% (2.7)	as Cat /u/ 96% (4.7)
Velar						
Less experienced	as Cat /i/ 99% (5.6)	as Cat /e/ 38% (4.4) as Cat /ɛ/ 29% (4.9) as Cat /i/ 28% (5)	as Cat /a/ 46% (4.3) as Cat /ɛ/ 28% (4)	as Cat /a/ 89% (5.4)	as Cat /u/ 75% (4.9) as Cat /ɔ/ 14% (4.5) as Cat /o/ 8% (4.7)	as Cat /u/ 95% (5.1)
More experienced	as Cat /i/ 99% (5.8)	as Cat /i/ 55% (3.8) as Cat /e/ 28% (3.9)	as Cat /ɛ/ 56% (5) as Cat /a/ 24% (3.6)	as Cat /a/ 93% (5.7)	as Cat /u/ 75% (4.2) as Cat /o/ 9% (2.7)	as Cat /u/ 100% (5.2)

4. DISCUSSION

In general, the results replicate findings from previous research on the perceptual assimilation of English vowels by Catalan speakers in terms of the main patterns of assimilation (Rallo Fabra, 2005; Cebrian, 2006, 2009; Cebrian, Mora & Aliaga-Garcia, 2011). Interestingly, the modal responses of the present study resemble the results reported by Cebrian (2009), even though that study used Canadian English stimuli and

this study used British English stimuli. Both studies showed high assimilation of English vowels /i/, /æ/ and /u/ to Catalan vowels /i/, /a/, /u/. Taking into account the results of experience and context variables it can be noted that L2 vowels which are highly assimilated to L1 vowels are not affected by L2 experience or by consonantal context. Thus, it can be deduced that experience and/or consonantal context will mostly affect those L2 vowels that have lower assimilation or no clear mapping to L1 categories. It is also worth mentioning that the rest of the results are also similar to the findings in Cebrian (2009), which showed relatively high assimilation of English /ʊ/ to Catalan /u/, and English /ɪ/ and /ɛ/ with no clear mapping to a single Catalan category.

4.1. Effects of language experience

The comparison between the responses for both groups of participants, the native Catalan speakers with little knowledge of English (the inexperienced group) and the Catalan L2 English learners (the experienced group), suggests that there is no apparent experience effect on the perceived assimilation of L2 sounds to L1 sounds in general. There are numerical differences between the two proficiency groups; in many cases the experienced group seemed more consistent with their responses but apparently there are no considerable variations. The only noticeable difference worth mentioning is the fact that the English vowel /ɛ/ was more identified as Catalan /a/ (60%) by the inexperienced group but as Catalan /ɛ/ (48%) by the experienced group. This finding does not match previous research but, as it will be discussed in the following section, the difference might be caused by consonantal context. A possible explanation could be that English /ɛ/ is similar to Catalan /ɛ/ and /a/ but it has no clear match to any of them. However, the inexperienced group, who seemed to show greater consonantal context effect, would perceive English /ɛ/ as lower in alveolar and velar context and hence, as

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closer to Catalan /a/. Of course, these are only mere assumptions and this issue should be explored further in future research.

4.2. Effects of consonantal context (Place and Voicing)

As it has been explained in the introduction, both voicing and place of articulation of the consonantal context surrounding a vowel affect the formant frequencies of the vowel. The second aim of this study was to examine if consonantal context affected native Catalan speakers' perceptual assimilation of English vowels to Catalan vowels, and to what extent. As expected, consonantal context effects were more noticeable with those English vowels with no clear mapping to Catalan categories and this was mostly visible in the responses by the inexperienced group. For instance, front vowels have a lower F2 (i.e. they are less fronted) in labial context (Hillenbrand & Clark, 2001). This context effect applied to the experienced group that provided lower assimilation scores for English /ɪ/, which was identified as Catalan /i/ with lower assimilation scores (58%) in labial (and velar) than in alveolar context (76%). The inexperienced group went one step further and assimilated English /ɪ/ to Catalan /i/ in alveolar context (63%) but to Catalan /e/, which is less fronted, in labial context (39%) (and in velar context to a lesser extent). Another vowel that seemed to be influenced by context was English /ɛ/. According to Hillenbrand & Clark (2001), English /ɛ/ has higher F1 (i.e. it is lower) in alveolar/velar contexts. The experienced group did not seem to be influenced by context, since the group assimilated English /ɛ/ to Catalan /ɛ/ in alveolar/velar contexts (52-56%) and to Catalan /a/ in labial context (51%). However, the inexperienced group assimilated English /ɛ/ to Catalan /a/, which is a lower vowel, in all three consonantal contexts.

Hillenbrand & Clark (2001) also mentioned that back vowels such as English /ʊ/ have lower F1 (i.e. they are higher) in voiced context. Again, this effect was not observed with the experienced group, since they assimilated English /ʊ/ to Catalan /u/ similarly (61-65%) in both voiced and voiceless contexts, but it was observed with the inexperienced group. The assimilation score increased from 52% in voiceless context to 82% in voiced context.

Up to this point, influence of the consonantal context on the assimilation of English vowels /ɪ/, /ɛ/ and /ʊ/ was detected in the participants' responses and they were mostly noticeable in the responses of the unexperienced group, as we hypothesized. Conversely, not only voicing effects but also place effects were found in the assimilation of English /ʊ/, although this time it was the experienced group that seemed to be influenced by context. Back vowels such as English /ʊ/ have higher F2 (i.e. they are more fronted) in alveolar context, thus the experienced group assimilated English /ʊ/ to Catalan /u/ in labial and velar contexts (68-75%), but the assimilation score decreased in alveolar context (47%) and increased for Catalan /i/ (up to 20%). One possibility would be that more advanced learners are more familiar with the fronting of English /u/ in alveolar context and thus they have a tendency to perceive English /ʊ/ more as Catalan /i/. However, the small percentage seems to indicate that this is only a small tendency.

It appears that these results point to the possibility that context affects the less experienced learners to a greater extent, in support to our hypothesis. Nevertheless, the differences observed between the two proficiency groups are not large and basically only seem to concern the assimilation of English /ɛ/ to Catalan /a/ by the inexperienced group but as Catalan /ɛ/ by the experienced group, which globally lends little support to

the theoretical effect of L2 experience and consonantal context on perceptual assimilation of English vowels.

5. LIMITATIONS AND FURTHER RESEARCH

This study provided insightful information on the field of cross-language perceptual assimilation. However, it had a number of limitations that need to be discussed. One of the limitations was the small sample (only 10-12 participants per group) due to a lack of availability of more participants. It is possible that greater differences emerged with a larger sample, which points to directions for further study.

In addition, no proficiency tests were run before the task and, although the participants of the inexperienced group reported having little knowledge of English, they were probably exposed to English to a certain extent due to globalization (internet, social networks, TV series and films in original version, online games, etc.). Thus, testing true monolinguals would be a logical step further to test experience effects and context effects on perceptual assimilation.

Another limitation worth mentioning is the fact that this study only looked at consonantal place differences, and only in a limited number of contexts. The main basis of this kind of research is that generalization cannot be made beyond the context that has been used for testing. Thus, more consonantal place contexts and even other consonantal characteristics could be explored in order to look for more possible context effects.

The main limitation of this study was the inability to check 'significance' in the variation of the results (due to lack of time) between contexts and proficiency groups. For that reason, we could only work on assumptions when interpreting the results.

Therefore, statistics should be run in order to look for significant differences. Another major limitation was the fact that this was the first study which explored the effect of place on cross-language perceptual assimilation of English vowels to Catalan categories. Since there is a lack of research on this specific area in Catalan, context results could not be compared to similar research. Despite its limitations, this study opened fresh areas of study that would be appealing to explore in further research.

6. CONCLUSION

The aim of this study was to explore the effects of consonantal context and L2 experience on Catalan speakers' perceptual assimilation of English vowels by means of a Perceptual Assimilation Task. The lack of consonantal context effect and/or experience effect on those English vowels that were highly assimilated to Catalan categories (English /i/, /æ/, /u/ as Catalan /i/, /a/, /u/) seemed to predict that these two factors only affect those L2 vowels with lower assimilation or no clear mapping to any L1 vowel category (English /ʊ/, /ɪ/ and /ɛ/). In fact, effects of consonantal context were mostly identified in the responses of the inexperienced group. On the other hand, the experienced group seemed to be minimally affected by context (except for the assimilation of English /ʊ/ as Catalan /i/ in a small tendency) and was more consistent in their mapping of responses, in support of Rallo Fabra's (2005) and Levy's (2009). However, the little variability in the responses between the proficiency levels and the consonantal contexts seems to indicate that these two factors do not have an influence on listeners' perceptual assimilation, as Cebrian (2009) reported. An exception was English /ɛ/, which was assimilated to Catalan /ɛ/ or /a/ depending on the proficiency group, although experience effect could not be proved, which is left for further research.

7. BIBLIOGRAPHY

- Best, C. T. 1994. "The Emergence of Native-Language Phonological Influence in Infants: A Perceptual Assimilation Model". Goodman, C. , & Nusbaum, N.C. (eds.). *The Development of Speech Perception.* Cambridge, MA: The MIT Press, 167-244.
- Best, C. 1995. A direct realist view of cross-language speech perception. A W. Strange (ed.), *Speech perception and linguistic experience: Issues in cross language research.* Timonium, MD: York Press, 171-204.
- Best, C. T., & Tyler, M. T. 2007. "Nonnative Second-Language Speech Perception". Bohn, O-S, & Munro, M.J. (eds.) *Language Experience in Second Language Speech Learning: In Honor of James E. Flege.* Amstendam: John Benjamins, 13-34.
- Boersma, P. & David, W. 2014. Praat: doing phonetics by computer [Computer program]. Version 5.3.71. http://www.praat.org/ (retrieved 18 May 2014)
- Bohn, O-S, & Steinlen, A. K. 2003. "Consonantal Context affects Cross Language Perception of Vowels". Recasens, D., & Solé, M.J. (eds.). *Proceedings of the XV International Congress of Phonetic Sciences.* Barcelona: Causal Productions, 2289-2292.
- Cebrian, J. 2006. "Experience and the use of duration in the categorization of L2 vowels". *Journal of Phonetics* 34, 372-387.
- Cebrian, J. 2009. "Effects of native language and amount of experience on crosslinguistic perception. *Journal of the Acoustical Society of America*, 125, No. 4: 2775.
- Cebrian, J., Mora, J.C. & Aliaga-Garcia, C. 2011. "Assessing crosslinguistic similarity by means of rated dissimilarity and perceptual assimilation tasks." Wrembel, M., Kul, M., Dziubalska-Kołaczyk, K. (eds.), *Achievements and perspectives in the acquisition of second language speech: New Sounds 2010.* Frankfurt am Main: Peter Lang, Vol. 1, 41-52
- Cebrian, J. 2014. "Perceptual Assimilation of English vowels and diphthongs by Chilean Spanish speakers". Paper presented at the International Workshop on Cross-Language Speech Perception, held at the Universidade do Minho, Braga, Portugal.
- Flege, J. E. 1995. "Second Language Speech Learning: theory, Findings and Problems". Strange, W. (ed.), *Speech Perception and Linguistic Experience*. Baltimore: York Press, 233-277.
- Gottfried, T. L. 1984. "Effects of Consonant Context on the Perception of French Vowels." *Journal of Phonetics.* 12: 91-114.
- Hillenbrand, J.M. & Clark, M.J. 2001. "Effects of consonant environment on vowel formant patterns". *Journal of the Acoustical Society of America*, 109, No. 2: 748-763.
- Levy, E.S, & Strange, W. 2008. "Perception of French vowels by American English Adults with and without French language Experience." *Journal of Phonetics.* 36: 141-157.
- Levy, E.S. 2009. Language experience and consonantal context effects on perceptual assimilation of French vowels by American-English learners of French Language. Journal of Acoustical Society of America, 125: 1138-1152

- Rallo Fabra, L. 2005. "Predicting ease of acquisition of L2 speech sounds. A perceived dissimilarity test." *Vigo International Journal of Applied Linguistics.* 2: 75-109.
- Rallo Fabra, L. & Romero, J. 2012. Native Catalan learners' perception and production of English vowels. *Journal of Phonetics.* 40: 491-508.
- Recasens D. 1985. "Coarticulatory Patterns and degrees of coarticulatory resistance in Catalan CV sequences." *Language and Speech.* 2: 97-114
- Recasens D. 1990. "An Electropalatographic and Acoustic Study of Consonant-to-vowel coarticulation" *Haskins Laboratory Status Report on Speech research.* 102: 140-148
- Recasens D, Espinosa, A. 2006. "Dispersion and Variabilityof Catalan vowels". *Speech Communication.* 48: 645-666.
- Stevens, K.N., & House, A.S. 1963. "Perturbations of Vowel Articulations by Consonantal Context: An Acoustical Study". *Journal of Speech and hearing Research.* 6: 111-128
- Strange, W., Akahane-Yamada, R., Fitzgerald, B.. H., & Kubo, R. 1998. "Perceptual Assimilation of American English Vowels by Japanese Listeners". *Journal of Phonetics.* 26: 311-344
- Strange, W., Akahane-Yamada, R., Kubo, Re., Trent, S.A., & Nishi, K. 2001. "Effects of consonantal context on perceptual assimilation of American English vowels by Japanese listeners". *The Journal of the Acoustical Society of America.* Vol. 109, no. 4: 1691-1704.
- Strange, W., Bohn, O-S., Trent, S. A., McNair, M. C., & Bielec, C.. 1996. "Context and Speaker Effects in the Perceptual Assimilation of German Vowels by American Listeners." *Spoken Language.* Vol. 4: 2462-2465.

APPENDICES

APPENDIX A: Elicitation list

"It rhymes with deep. I say **hapeep**. I say **hapeep** again."
"It rhymes with tip. I say **hapip**. I say **hapip** again."
"It rhymes with step. I say **hapep**. I say **hapep** again."
"It rhymes with gap. I say **hapap**. I say **hapap** again."
"It contains the vowel in could. I say **hapoup**. I say **hapoup** again."
"It rhymes with loop. I say **hapoope**. I say **hapoope** again."

"It contains the vowel in beet. I say **habeeb**. I say **habeeb** again."
"It rhymes with rib. I say **habib**. I say **habib** again."
"It rhymes with ebb. I say **habeb**. I say **habeb** again."
"It rhymes with lab. I say **habab**. I say **habab** again."
"It contains the vowel in could. I say **haboub**. I say **haboub** again
"It rhymes with lube. I say **haboobe**. I say **haboobe** again."

"It rhymes with feet. I say **hateet**. I say **hateet** again."
"It rhymes with bit. I say **hatit**. I say **hatit** again."
"It rhymes with bet. I say **hatet**. I say **hatet** again."
"It rhymes with hat. I say **hatat**. I say **hatat** again."
"It rhymes with put. I say **hatut**. I say **hatut** again."
"It rhymes with toot. I say **hatoote**. I say **hatoote** again."

"It rhymes with speed. I say **hadeed**. I say **hadeed** again."
"It rhymes with kid. I say **hadid**. I say **hadid** again."
"It rhymes with bed. I say **haded**. I say **haded** again."
"It rhymes with bad. I say **hadad**. I say **hadad** again."
"It rhymes with could. I say **hadoud**. I say **hadoud** again."
"It rhymes with food. I say **hadoode**. I say **hadoode** again."

"It rhymes with peek. I say **hakeek**. I say **hakeek** again."
"It rhymes with pick. I say **hakik**. I say **hakik** again."
"It rhymes with deck. I say **hakek**. I say **hakek** again."
"It rhymes with back. I say **hakak**. I say **hakak** again."
"It rhymes with book. I say **hakook**. I say **hakook** again."
"It rhymes with fluke. I say **hakooke**. I say **hakooke** again."

"It rhymes with league. I say **hageague**. I say **hageague** again."
"It rhymes with dig. I say **hagig**. I say **hagig** again."
"It rhymes with beg. I say **hageg**. I say **hageg** again."
"It rhymes with bag. I say **hagag**. I say **hagag** again."
"It contains the vowel in could. I say **hagoug**. I say ha**goug** again."
"It contains the vowel in fluke. I say **hagoog**. I say **hagoog** again."

APPENDIX B: Language background questionnaire

- Nom:

- Edat:

- Lloc de residència:

- Estudis (curs actual):

- Quina és la teva Llengua Materna?

a) Català   b) Castellà   c) Totes dues

- Quina variant del català parles? Escriu la província / regió.

    (Si la teva resposta a la pregunta anterior es "Castellà" no cal que responguis

    aquesta pregunta)

- Quina és la llengua materna del teu pare?

- Quina és la llengua materna de la teva mare?

Indica la llengua que fa servir més sovint...

Amb la família   Amb els amics   A la feina   A la universitat

- A quina edat vas començar a aprendre anglès?

- Continues estudiant anglès en l'actualitat?   SÍ   NO

- Quins estudis d'anglès tens? (especifica)

- Has estat en algun país de parla anglesa?   SÍ   NO

On?

Quan? Quant de temps?

- Parles anglès amb fluïdesa?   SÍ   NO

- Has cursat alguna assignatura de Fonètica Anglesa?   SÍ   NO

- En quines situacions fas servir l'anglès actualment?

  a) Només a classe

  b) A la feina

c) Altres (especifica):

-Parles amb fluïdesa alguna altre llengua estrangera a part de l'anglès?   SÍ   NO

Quina /Quines?

- Tens cap problema que afecti la teva capacitat auditiva?

APPENDIX C: Consent form

Universitat Autònoma de Barcelona
Department of English Philology

Consent form

I, _____ agree to take part in a study on vowel perception.

I understand that the experiment will take about 30 minutes and will occur at a convenient time and place. I understand that I may withdraw from the study.

I understand that my name and my specific answers will remain confidential and that I will not be identified in any report or presentation which may arise from the study.

I understand that while I may not benefit directly from the study, the information gained may help achieve a better understanding of the process of language acquisition and may help improve methods of language learning.

I understand what this study involves and agree to participate

_____   _____

Date   Signature

_____

Witness

APPENDIX D: Full set of responses and results

Catalan speakers

Catalan responses	British English stimuli — i tense	I lax	e	ae	U lax	u tense	Total general
i							
Cuenta de response	99%	42%	2%	0%	1%	2%	24%
Promedio de goodness	5,7	5,0	3,4		5,7	4,0	5,4
Desvest de goodness	1,2	1,2	1,7		1,2	1,2	1,3
e tancada							
Cuenta de response	1%	32%	13%	2%	3%	1%	8%
Promedio de goodness	5,5	4,3	4,3	4,8	4,7	4,5	4,4
Desvest de goodness	0,7	1,3	1,6	1,0	1,7	2,1	1,4
e oberta							
Cuenta de response	0%	20%	17%	4%	5%	0%	8%
Promedio de goodness		4,6	4,0	3,3	4,8		4,3
Desvest de goodness		1,0	1,1	1,2	1,2		1,1
a							
Cuenta de response	0%	1%	60%	85%	2%	0%	25%
Promedio de goodness	7,0	3,7	4,6	5,2	3,4		4,9
Desvest de goodness	#iDIV/0!	1,2	1,4	1,4	1,7		1,5
o oberta							
Cuenta de response	0%	0%	4%	8%	11%	3%	4%
Promedio de goodness		3,0	4,4	5,1	4,6	3,6	4,5
Desvest de goodness		#iDIV/0!	1,5	1,0	1,1	1,0	1,2
o tancada							
Cuenta de response	0%	0%	3%	2%	11%	1%	3%
Promedio de goodness			4,0	6,0	4,3	3,5	4,4
Desvest de goodness			1,5	0,8	1,2	2,1	1,4
u							
Cuenta de response	0%	5%	1%	0%	67%	94%	28%
Promedio de goodness		4,3	4,5	4,0	4,9	5,2	5,0
Desvest de goodness		1,4	2,1	#iDIV/0!	1,3	1,3	1,3
Total Cuenta de response	100%	100%	100%	100%	100%	100%	100%
Total Promedio de goodness	5,7	4,6	4,4	5,1	4,8	5,1	5,0
Total Desvest de goodness	1,2	1,2	1,4	1,4	1,3	1,3	1,4

Catalan L2 English learners

Catalan responses	British English stimuli — i tense	I lax	e	ae	U lax	u tense	Total general
i							
Cuenta de response	100%	63%	1%	0%	7%	1%	29%
Promedio de goodness	5,9	4,0	1,8		2,9	2,5	5,0
Desvest de goodness	1,2	1,6	0,5		1,2	0,6	1,7
e tancada							
Cuenta de response	0%	27%	11%	0%	8%	0%	8%
Promedio de goodness		4,0	4,2		2,8		3,8
Desvest de goodness		1,6	1,4		1,2		1,5
e oberta							
Cuenta de response	0%	10%	48%	3%	3%	0%	11%
Promedio de goodness	3,0	4,7	5,1	4,0	3,7	5,0	4,9
Desvest de goodness	#iDIV/0!	1,5	1,6	1,6	1,3	#iDIV/0!	1,6
a							
Cuenta de response	0%	0%	39%	94%	0%	0%	22%
Promedio de goodness			3,8	5,4	1,0		4,9
Desvest de goodness			1,6	1,4	#iDIV/0!		1,7
o oberta							
Cuenta de response	0%	0%	0%	3%	5%	0%	1%
Promedio de goodness			1,0	5,6	3,7		4,2
Desvest de goodness			#iDIV/0!	1,5	1,2		1,7
o tancada							
Cuenta de response	0%	0%	0%	0%	13%	0%	2%
Promedio de goodness					3,0		3,0
Desvest de goodness					1,7		1,7
u							
Cuenta de response	0%	0%	0%	0%	63%	98%	27%
Promedio de goodness					3,9	5,1	4,7
Desvest de goodness					1,6	1,7	1,8
Total Cuenta de response	100%	100%	100%	100%	100%	100%	100%
Total Promedio de goodness	5,9	4,1	4,5	5,4	3,6	5,1	4,7
Total Desvest de goodness	1,3	1,6	1,7	1,5	1,6	1,7	1,8

Catalan speakers

Catalan responses	i tense voiced	i tense voiceless	Total i tense	I lax voiced	I lax voiceless	Total I lax	e voiced	e voiceless	Total e	ae voiced	ae voiceless	Total ae	U lax voiced	U lax voiceless	Total U lax	u tense voiced	u tense voiceless	Total u tense	Total general
i Cuenta de response	99%	98%	99%	47%	37%	42%	2%	3%	2%	0%	0%	0%	0%	3%	1%	2%	2%	2%	24%
Promedio de goodness	5,7	5,7	5,7	5,2	4,8	5,0	2,0	4,3	3,4					5,7	5,7	4,0	4,0	4,0	5,4
Desvest de goodness	1,2	1,2	1,2	1,0	1,3	1,2	1,4	1,2	1,7					1,2	1,2	1,4	1,4	1,2	1,3
e tancada Cuenta de response	1%	1%	1%	29%	34%	32%	13%	13%	13%	2%	2%	2%	1%	5%	3%	0%	2%	1%	8%
Promedio de goodness	5,0	6,0	5,5	4,1	4,4	4,3	4,0	4,6	4,3	4,5	5,0	4,8	2,0	5,2	4,7		4,5	4,5	4,4
Desvest de goodness	#iDIV/0!	#iDIV/0!	0,7	1,2	1,3	1,3	1,7	1,5	1,6	0,7	1,4	1,0 #iDIV/0!	#iDIV/0!	1,3	1,7		2,1	2,1	1,4
e oberta Cuenta de response	0%	0%	0%	15%	25%	20%	17%	19%	17%	3%	5%	4%	5%	5%	5%	0%	0%	0%	8%
Promedio de goodness				4,6	4,7	4,7	4,0	4,0	4,0	3,3	3,3	3,3	4,8	4,3	4,8				4,3
Desvest de goodness				0,9	1,1	1,0	1,1	1,1	1,1	1,5	1,2	1,2	1,2	1,5	1,2				1,1
a Cuenta de response	0%	1%	0%	2%	1%	1%	58%	62%	60%	88%	82%	85%	1%	3%	2%	0%	0%	0%	25%
Promedio de goodness		7,0	7,0	4,0	3,0	3,7	4,6	4,6	4,6	5,2	5,2	5,2	4,0	3,3	3,4				4,9
Desvest de goodness		#iDIV/0!	#iDIV/0!	1,4	#iDIV/0!	1,2	1,3	1,4	1,4	1,4	1,4	1,4	#iDIV/0!	1,9	1,7				1,5
o oberta Cuenta de response	0%	0%	0%	0%	1%	0%	3%	5%	4%	6%	9%	8%	6%	17%	11%	2%	4%	3%	4%
Promedio de goodness					3,0	3,0	4,0	4,7	4,4	5,4	4,8	5,1	4,1	4,7	4,6	4,0	3,4	3,6	4,5
Desvest de goodness					#iDIV/0!	#iDIV/0!	2,0	1,4	1,5	0,8	1,1	1,0	0,9	1,1	1,1	0,0	1,1	1,0	1,2
o tancada Cuenta de response	0%	0%	0%	0%	0%	0%	4%	3%	3%	2%	2%	2%	6%	16%	11%	1%	1%	1%	3%
Promedio de goodness							3,6	4,7	4,0	6,5	5,5	6,0	4,4	4,3	4,3	5,0	2,0	3,5	4,4
Desvest de goodness							1,5	1,5	1,5	0,7	0,7	0,8	1,7	1,0	1,2 #iDIV/0!	#iDIV/0!	2,0	2,1	1,4
u Cuenta de response	0%	0%	0%	8%	3%	5%	2%	0%	1%	0%	1%	0%	82%	52%	67%	96%	92%	94%	28%
Promedio de goodness				4,3	4,0	4,3	4,5		4,5		4,0	4,0	5,0	4,8	4,9	5,2	5,1	5,2	5,0
Desvest de goodness				1,5	1,0	1,4	2,1		2,1 #iDIV/0!		#iDIV/0! #iDIV/0!	#iDIV/0!	1,3	1,4	1,3	1,3	1,2	1,3	1,3
Total Cuenta de response	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Total Promedio de goodness	5,7	5,7	5,7	4,7	4,6	4,6	4,3	4,5	4,4	5,2	5,1	5,1	4,9	4,7	4,8	5,1	5,0	5,1	5,0
Total Desvest de goodness	1,2	1,2	1,2	1,2	1,2	1,2	1,4	1,4	1,4	1,4	1,4	1,4	1,3	1,4	1,3	1,4	1,3	1,3	1,4

Catalan L2 English learners

Catalan responses	i tense voiced	i tense voiceless	Total i tense	I lax voiced	I lax voiceless	Total I lax	e voiced	e voiceless	Total e	ae voiced	ae voiceless	Total ae	U lax voiced	U lax voiceless	Total U lax	u tense voiced	u tense voiceless	Total u tense	Total general
i Cuenta de response	100%	99%	100%	59%	67%	63%	1%	2%	1%	0%	0%	0%	5%	9%	7%	1%	1%	1%	29%
Promedio de goodness	5,8	6,0	5,9	3,9	4,1	4,0	2,0	1,7	1,8				2,3	3,2	2,9	2,5	2,5	2,5	5,0
Desvest de goodness	1,3	1,1	1,2	1,4	1,7	1,6	#iDIV/0!	0,6	0,5				1,1	1,2	1,2	0,7	0,7	0,6	1,7
e tancada Cuenta de response	0%	0%	0%	33%	20%	27%	14%	8%	11%	3%	3%	3%	8%	8%	8%	0%	0%	0%	8%
Promedio de goodness				4,0	4,0	4,0	4,1	4,3	4,2	4,0	5,6	5,0	2,8	2,8	2,8				3,8
Desvest de goodness				1,5	1,7	1,6	1,6	1,2	1,4	1,6	1,5	1,8	1,3	1,2	1,2				1,5
e oberta Cuenta de response	0%	1%	0%	8%	13%	10%	44%	52%	48%	3%	3%	3%	2%	5%	3%	1%	1%	1%	11%
Promedio de goodness	3,0	3,0	3,0	4,1	5,1	4,7	5,0	5,2	5,1	4,2	3,8	4,0	4,7	3,3	3,7	5,0	5,0	5,0	4,9
Desvest de goodness	#iDIV/0!	#iDIV/0!	#iDIV/0!	1,6	1,4	1,5	1,7	1,6	1,6	1,5	1,8	1,6	1,2	1,1	1,3 #iDIV/0!	#iDIV/0!	#iDIV/0!	#iDIV/0!	1,6
a Cuenta de response	0%	0%	0%	0%	0%	0%	40%	38%	39%	94%	94%	94%	1%	0%	0%	0%	0%	0%	22%
Promedio de goodness							3,6	4,2	3,8	5,3	5,5	5,4	1,0		1,0				4,9
Desvest de goodness							1,5	1,7	1,6	1,5	1,4	1,4	#iDIV/0!		#iDIV/0!				1,7
o oberta Cuenta de response	0%	0%	0%	0%	0%	0%	1%	0%	0%	3%	3%	3%	5%	6%	5%	0%	0%	0%	1%
Promedio de goodness							1,0	1,0	1,0	5,0	6,3	5,6	3,7	3,7	3,7				4,2
Desvest de goodness							#iDIV/0!	#iDIV/0!	#iDIV/0!	1,8	1,0	1,5	1,4	1,1	1,2				1,7
o tancada Cuenta de response	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	14%	11%	13%	0%	0%	0%	2%
Promedio de goodness													3,1	2,9	3,0				3,0
Desvest de goodness													1,8	1,5	1,7				1,7
u Cuenta de response	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	65%	61%	63%	98%	99%	98%	27%
Promedio de goodness													4,1	3,8	3,9	5,1	5,2	5,1	4,7
Desvest de goodness													1,7	1,6	1,6	1,7	1,8	1,7	1,8
Total Cuenta de response	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total Promedio de goodness	5,8	6,0	5,9	3,9	4,2	4,1	4,2	4,7	4,5	5,3	5,4	5,4	3,7	3,5	3,6	5,0	5,2	5,1	4,7
Total Desvest de goodness	1,3	1,2	1,3	1,4	1,7	1,6	1,7	1,7	1,7	1,5	1,4	1,5	1,7	1,5	1,6	1,6	1,9	1,7	1,8

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Catalan speakers

Catalan responses	Br Eng stimt ▾ i tense		Total i tense		I lax		Total I lax		e		Total e ⊞ ae		ae		Total ae ⊞ U lax		U lax		Total U lax ⊞ u tense		u tense		Total u tense	Total general
	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless		
i																								
Cuenta de response	99%	98%	99%		47%	37%	42%			3%			2%		0%		3%		1%		2%	2%	2%	24%
Promedio de goodness	5,7	5,7	5,7		5,2	4,8	5,0			4,3			3,4				5,7		5,7		4,0	4,0	4,0	5,4
Desvest de goodness	1,2	1,2	1,2		1,0	1,3	1,2			1,2			1,7				1,2		1,2		1,4	1,4	1,2	1,3
e tancada																								
Cuenta de response	1%	1%	1%		29%	34%	32%		13%	13%	2%	2%	2%	2%	1%	3%	1%	5%	0%				1%	8%
Promedio de goodness	5,0	6,0	5,5		4,1	4,4	4,3		4,3	4,6	4,5	5,0	4,8	5,2	2,0	4,7	2,0	4,6					4,5	4,4
Desvest de goodness	#¡DIV/0!	#¡DIV/0!	0,7		1,2	1,3	1,3		1,6	1,5	0,7	1,4	1,4	1,3	#¡DIV/0!	1,1		1,7					2,1	1,4
e oberta																								
Cuenta de response	0%	0%	0%		15%	25%	20%		17%	19%	3%	5%	4%	5%	5%	5%	5%	5%	0%		0%	0%	0%	8%
Promedio de goodness					4,6	4,7	4,6		4,0	4,0	3,3	3,3	3,3	3,3	5,2	4,3	5,2	4,3						4,3
Desvest de goodness					0,9	1,1	1,0		1,1	1,1	1,5	1,2	1,2	1,2	0,8	1,5	0,8	1,5						1,1
a																								
Cuenta de response	0%	1%	0%		2%	1%	1%		58%	62%	88%	82%	85%	82%	1%	3%	1%	2%	0%		0%		0%	25%
Promedio de goodness		7,0	7,0		4,0	3,0	3,7		4,6	4,6	5,2	5,2	5,2	5,2	4,0	3,3	4,0	3,4						4,9
Desvest de goodness		#¡DIV/0!	#¡DIV/0!		1,4	#¡DIV/0!	1,2		1,3	1,4	1,4	1,4	1,4	1,4	#¡DIV/0!	1,9	#¡DIV/0!	1,7						1,5
o oberta																								
Cuenta de response	0%	0%	0%		0%	1%	0%		0%	5%	6%	9%	8%	6%	6%	17%	6%	11%	2%		2%	4%	3%	4%
Promedio de goodness						3,0	3,0			4,0	5,4	4,8	5,1	4,4	4,1	4,7	4,1	4,6	4,0		4,0	3,4	3,6	4,5
Desvest de goodness						#¡DIV/0!	#¡DIV/0!			2,0	0,8	1,1	1,0	1,5	0,9	1,1	0,9	1,1	0,0		0,0	1,1	1,0	1,2
o tancada																								
Cuenta de response	0%	0%	0%		0%	0%	0%		4%	3%	2%	2%	2%	2%	6%	16%	6%	11%	1%		1%	1%	1%	3%
Promedio de goodness									3,6	4,7	6,5	5,5	6,0	4,4	4,4	4,3	4,4	4,3	5,0		5,0	2,0	3,5	4,4
Desvest de goodness									1,5	1,5	0,7	0,7	0,8	1,7	1,0	1,2	1,0	1,2	#¡DIV/0!		#¡DIV/0!	#¡DIV/0!	2,1	1,4
u																								
Cuenta de response	0%	0%	0%		8%	3%	5%		5%	0%	0%	1%	0%	1%	82%	52%	67%	67%	96%	92%	96%	92%	94%	28%
Promedio de goodness					4,3	4,0	4,3		4,3			4,0		4,0	5,0	4,8	5,0	4,9	5,2	5,1	5,2	5,1	5,2	5,0
Desvest de goodness					1,5	1,0	1,4		1,4			2,1		2,1	1,3	1,4	1,3	1,3	1,4	1,2	#¡DIV/0!	#¡DIV/0!	1,3	1,3
Total Cuenta de response	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Total Promedio de goodness	5,7	5,7	5,7	5,7	4,7	4,6	4,6	4,5	4,3	4,5	5,2	5,1	5,1	4,9	4,9	4,7	4,8	5,0	5,1	5,0	5,0	5,0	5,0
Total Desvest de goodness	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,4	1,4	1,4	1,4	1,4	1,4	1,3	1,3	1,3	1,3	1,4	1,4	1,3	1,4	1,3	1,4

Catalan L2 English learners

Catalan responses	Br Eng stimt ▾ i tense		Total i tense		I lax		Total I lax		e		Total e ⊞ ae		ae		Total ae ⊞ U lax		U lax		Total U lax ⊞ u tense		u tense		Total u tense	Total general
	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless	voiced	voiceless		
i																								
Cuenta de response	100%	99%	100%		59%	67%	63%		1%	2%	1%	0%	0%	0%	5%	9%	7%	7%	1%	1%	1%	1%	1%	29%
Promedio de goodness	5,8	6,0	5,9		3,9	4,1	4,0		1,8	1,7	1,8				2,3	3,2	2,9	2,9	2,5	2,5	2,5	2,5	2,5	5,0
Desvest de goodness	1,3	1,1	1,2		1,4	1,7	1,6	#¡DIV/0!	0,5	0,6	0,5				1,1	1,2	1,2	1,2	0,7	0,7	0,6	0,7	0,6	1,7
e tancada																								
Cuenta de response	0%	0%	0%		33%	20%	27%		11%	8%	11%	0%	0%	0%	8%	8%	8%	8%	0%	0%	0%	0%	0%	8%
Promedio de goodness					4,0	4,0	4,0		4,2	4,3	4,2				2,8	2,8	2,8	2,8						3,8
Desvest de goodness					1,5	1,7	1,6		1,4	1,2	1,4				1,3	1,2	1,2	1,2						1,5
e oberta																								
Cuenta de response	0%	1%	0%		8%	13%	10%		48%	52%	44%	3%	3%	3%	2%	5%	3%	3%	1%	1%	1%	0%	0%	11%
Promedio de goodness		3,0	3,0		4,1	5,1	4,7		5,1	5,2	5,0	4,2	4,0	4,7	4,7	3,3	3,7	3,7	5,0	5,0	5,0		5,0	4,9
Desvest de goodness	#¡DIV/0!	#¡DIV/0!	#¡DIV/0!		1,6	1,4	1,5		1,6	1,6	1,7	1,5	1,6	1,2	1,1	1,1	1,3	1,2	#¡DIV/0!	#¡DIV/0!	#¡DIV/0!		#¡DIV/0!	1,6
a																								
Cuenta de response	0%	0%	0%		0%	0%	0%		39%	38%	40%	94%	94%	94%	1%	0%	1%	0%	0%	0%	0%		0%	22%
Promedio de goodness									3,8	4,2	3,6	5,5	5,4	5,4	1,0		1,0	1,0						4,9
Desvest de goodness									1,6	1,7	1,5	1,4	1,4	1,4	#¡DIV/0!		#¡DIV/0!	#¡DIV/0!						1,7
o oberta																								
Cuenta de response	0%	0%	0%		0%	0%	0%		0%	0%	0%	3%	3%	3%	5%	6%	5%	5%	0%	0%	0%	0%	0%	1%
Promedio de goodness									1,0		1,0	5,0	6,3	5,6	3,7	3,6	3,7	3,7						4,2
Desvest de goodness									#¡DIV/0!		#¡DIV/0!	1,8	1,0	1,5	1,4	1,1	1,4	1,2						1,7
o tancada																								
Cuenta de response	0%	0%	0%		0%	0%	0%		0%	0%	0%	0%	0%	0%	14%	11%	13%	13%	0%	0%	0%	0%	0%	2%
Promedio de goodness															3,1	2,9	3,0	3,0						3,0
Desvest de goodness															1,8	1,5	1,7	1,7						1,7
u																								
Cuenta de response	100%	100%	100%		100%	100%	100%		100%	100%	100%	100%	100%	100%	65%	61%	63%	63%	98%	99%	98%	98%	98%	27%
Promedio de goodness	5,8	6,0	5,9		3,9	4,2	4,1		4,5	4,7	4,5	5,4	5,4	5,3	4,1	3,8	3,9	3,9	5,1	5,2	5,1	5,1	5,1	4,7
Desvest de goodness	1,3	1,2	1,3		1,4	1,7	1,6		1,7	1,7	1,7	1,4	1,4	1,5	1,7	1,6	1,6	1,6	1,6	1,8	1,6	1,8	1,7	1,8
Total Cuenta de response	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total Promedio de goodness	5,8	6,0	5,9		3,9	4,2	4,1		4,5	4,7	4,5	5,4	5,4	5,3	3,7	3,5	3,6	3,6	5,0	5,2	5,0	5,1	5,1	4,7
Total Desvest de goodness	1,3	1,2	1,3	1,4	1,4	1,7	1,6	1,7	1,7	1,7	1,5	1,4	1,5	1,7	1,7	1,5	1,6	1,6	1,6	1,9	1,6	1,7	1,7	1,8