Bidirectional influence on L1 Spanish and L2 English stop perception: The role of L2 experience

Celia Gorba
Departament de Filologia Anglesa i Germanística, Universitat Autònoma de Barcelona, Facultat de Filosofia i Lletres, Campus UAB, Bellaterra 08193, Spain
celia.gorba@uab.cat

Abstract: Previous research found that second language (L2) experience may cause an interaction between first language (L1) and L2 categories. This study examines the effect of L2 experience on L1 and L2 stop perception. Three groups of Spanish learners of English varying in L2 experience completed a /p/-/b/ identification task—which included stimuli varying along a Voice Onset Time continuum—in each language. Results suggested that L2 experience improves the perception of L2 stops, but that it also affects L1 perception. Moreover, all groups appeared to have a shared L1-L2 category for bilabial stops, as perception patterns did not differ between languages.

© 2019 Acoustical Society of America
[RS]
Date Received: March 29, 2019 **Date Accepted:** June 6, 2019

1. Introduction

Most second language (L2) speech models, such as the Perceptual Assimilation Model (PAM-L2; Best and Tyler, 2007), the Speech Learning Model (SLM; Flege, 1995), or the Second Language Linguistic Perception Model (Escudero, 2005) claim that the acquisition of an L2 may cause cross-linguistic influence, that is, an influence of the existing first language (L1) on the target language, as well as an effect of L2 on L1. Flege's SLM posits that category formation of an L2 phone may be blocked if it is similar to an existing L1 phone. Initially, the L2 category will be "assimilated" to the closest L1 phone. The category may then develop to show properties of both L1 and L2. This study explores the issue of bidirectional L1-L2 influence by examining the perception of L1 and L2 stops by Spanish learners of English with different amounts of L2 experience.

Language experience has been defined in different ways in the literature (e.g., years of instruction, length of residence in the target-language context, and L2 use). In the present paper, L2 experience is understood as the length of residence in an immersion setting (e.g., Flege, 1987). Following PAM-L2's (Best and Tyler, 2007) proposal, L2 learners who have lived in an L2 setting for at least 6 months are considered to be L2 experienced. A few studies have assessed the effect of L2 experience on L2 perception (e.g., Flege *et al.*, 1997; Levy and Law, 2010; Gorba, 2018). For instance, Flege *et al.* (1997) found that highly experienced L2 speakers of English with different L1s (i.e., German, Spanish, Mandarin, and Korean), who had spent between 5 and 9 years in the U.S., perceived the /ɛ/-/æ/ contrast in a more native-like manner than inexperienced (INEXP) learners with the same linguistic background. Gorba (2018) compared the perception and production of bilabial stops by Spanish learners of English with no experience abroad with a group of experienced L2 learners who had spent a mean of 12 months in the United Kingdom. Both groups of learners were living in Spain at the time of testing. The more experienced learners perceived /p/-/b/ more similarly to English speakers than Spanish INEXP learners.

Some previous studies have also found that L2 experience may influence L1 production. For instance, Flege (1987) found a bidirectional effect on experienced L2 learners living in an L2 context. That is, experienced English learners of French produced /t/ with intermediate Voice Onset Time (VOT) values in both languages. However, Riney and Okamura (1999) did not find L2 influence on L1 stop production by L2 experienced native English learners of Japanese. Evidence of L2 influence on L1 has also been reported for the perception of L1 categories (e.g., Hazan and Boulakia, 1993; Tice and Woodly, 2012; Williams, 1977) and L1 phonotactics (e.g., Cabrelli *et al.*, 2019; Carlson *et al.*, 2016). Still, few studies have evaluated if the potential effect of the L2 on L1 perception is modulated by the amount of L2 experience (e.g., Dimitrieva, 2019; Gorba, 2018). In line with Riney and Okamura (1999), Gorba (2018) failed to find significant differences between Spanish experienced and INEXP learners of English in their perception of the L1 /p/-/b/ contrast.

The goal of the present study is to investigate the effect of L2 experience on L1 and L2 stop perception. More specifically, L1 and L2 perception of the /p/-/b/ contrast by Spanish learners of English varying in the amount of L2 experience is analyzed. This study involves L2 experienced Spanish learners of English living in an L2 setting, as well as moderately experienced and INEXP Spanish learners of English in their home country. Participants had to complete two identification tasks—one in English and one in Spanish. If participants with greater L2 experience perform according to English monolingual values, results will indicate a positive effect of L2 experience on L2 stop perception. An influence of L2 experience on L1 stop perception will be shown if experienced groups obtain deviant results from Spanish controls (SPCONTs). In addition, similar L1 and L2 categories will indicate that L2 learners present a single shared category, whereas a different perception in each language will suggest that L2 learners are using separate categories.

2. Method

2.1 Participants

Twenty-nine Spanish learners of English completed the experiment. They belonged to three groups according to their amount of L2 experience (i.e., length of residence in the L2 country). Table 1 shows the main characteristics of the three groups, including number of participants, gender, L1, L2, amount of L2 experience, and setting. The INEXP group were students of English Studies at Universitat Autònoma de Barcelona (UAB) who had never lived in an English-speaking country. The group of experienced English learners living in Spain (EXP1) were last-year or recent graduate students of English Studies who had spent between a term and a full academic year in an English-speaking country as part of a study-abroad program. They were tested in Barcelona. Finally, the participants in the most experienced group (EXP2) had been living and working in London, the United Kingdom, for a mean of 4 years. Although most participants spoke Catalan in addition to Spanish, knowledge of Catalan should not have an effect on the perception of Spanish stops, since the two languages are reported to have virtually the same VOT values (Lisker and Abramson, 1964; Julià, 1981).

Moreover, a SPCONT group and an English control (ENCONT) group were tested. The SPCONTs were students of History and Spanish Studies at UAB who had little knowledge of English and who rarely used it. Finally, the nine ENCONTs were graduate and undergraduate students at Queen Mary University of London with minor or no knowledge of an L2.

2.2 Stimuli

A /pi/-/bi/ VOT continuum with 17 stimuli ranging from −30.4 to 57.9 ms was created to test the participants' categorical perception of the contrast, both in English and Spanish. The continuum was created by manually editing natural speech produced by a trained bilingual speaker of Spanish and English using Praat (Boersma and Weenink, 2016). In order to control other voicing cues, an ambiguous burst and vowel /i/ (i.e., selected and modified to present intermediate values between voiced and voiceless secondary cues, including duration, intensity, F1, and F0 contour) were used for the creation of the stimuli. The VOT range was decided upon the basis of the results from a preliminary experiment (Gorba, 2018), which had used a wider range of similar stimuli and had only controlled two secondary voicing cues (i.e., burst intensity and duration). Vowel /i/ was selected to follow the bilabial stop because it has been reported to be one of the most perceptually equivalent vowels in Spanish and English as judged by Spanish listeners (Cebrian, 2019). Prevoiced stimuli were created by adding cycles of prevoicing extracted from the same token in steps of about 5 ms.

Table 1. Characteristics of the four groups that participated in the study. SD = standard deviation.

Group	Number of participants	Gender	L1	L2	Amount of L2 experience (in months)	Location	Language Setting
ENCONT	9	4 F; 5 M	English	NA	NA	London (United Kingdom)	L1
EXP2	9	5 F; 4 M	Spanish	English	$M = 48$; $SD = 23.8$	London (United Kingdom)	L2
EXP1	10	7 F; 3 M	Spanish	English	$M = 8.6$; $SD = 9.7$	Barcelona (Spain)	L1
INEXP	10	6 F; 4 M	Spanish	English	none/minor	Barcelona (Spain)	L1
SPCONT	10	4 F; 6 M	Spanish	NA	NA	Barcelona (Spain)	L1

Similarly, aspirated tokens were created by inserting chunks of aspiration from the same production in steps that increased in 5 ms.

2.3 Tasks

The 17 stimuli were presented in a forced-choice two-alternative identification task under two conditions, namely, an English task and a Spanish task. In other words, the same stimuli were used to create an identification test in English and an identification test in Spanish. Thus, the English and Spanish versions of the task included the same stimuli but differed in the response alternatives. The labels used in the English task were "b" as in beetle and "p" as peeler, whereas in Spanish the options provided were "b como en bicho" (b as in bug) and "p como en pico" (p as in beak). Stimuli were repeated 4 times in a random order (resulting in a total of 68 trials) and were presented once at every given trial. Participants were able to replay each trial one more time if necessary. Tasks were administered using Praat (Boersma and Weenink, 2016). Both languages were tested in the same session and participants were greeted and given the instructions in the language that they were going to be tested first. Order of completion was counterbalanced, and participants had to carry out a production task in the target language before completing each identification test. The production experiment involved a carrier sentence reading task including words with initial bilabial stops, as well as fillers. Production results are not presented in this paper due to space limitations. Participants' background information was collected with an online questionnaire that was completed prior to the testing session.

3. Results

The measure used to quantify the categorical perception of /p/-/b/ was category boundary, that is, the point at which the listener stops hearing /b/ and starts perceiving /p/.[1] The English and Spanish /p/-/b/ category boundaries of each participant were calculated by converting their responses along the continuum in each language into a logistic function. The resulting constant (b0) and slope (b1) were used in the formula −LN(b0)/LN(b1) in order to obtain a numeric value for their boundary (Aliaga-García and Mora, 2009).

As the order of completion of the two tasks varied across participants—that is, whether the task was completed in Spanish or English first—it was examined if it could have influenced participants' perception. A two-way analysis of variance (ANOVA) was conducted for each language and revealed a significant effect of order in the case of the Spanish boundary [$F(1, 23) = 7.717$; $p = 0.011$]: participants who completed the English task first appeared to present category boundaries with greater VOT values in Spanish than those who did the Spanish task first. No significant effect of order was found for the English boundary [$F(1, 23) = 0.36$; $p = 0.550$]. This result may suggest that completing the task in English in the first place may influence the performance in the second task, but not the other way around. Still, due to the small sample (only four to five participants in each group per task and order of combination), it is difficult to assess the actual impact of order on bilinguals' perception. Further research is necessary to evaluate the role of task order.

3.1 English task

Figure 1 illustrates the mean boundaries observed for each group in English. As expected, English monolingual speakers have the category boundary with the highest VOT values (14 ms). The most experienced group (EXP2) obtained the closest value to that of ENCONT (12.1 ms), followed by EXP1 (10.1 ms), whereas the least experienced learners (INEXP) presented the lowest category boundary value (9.3 ms).

A one-way ANOVA was conducted to assess the effect of L2 experience (with group as the independent variable) on the location of the /p/-/b/ category boundary (dependent variable). A significant effect of group was found [$F(3,35) = 3.872$; $p = 0.017$]. *Post hoc* Bonferroni tests revealed a significant difference between ENCONT and INEXP ($p = 0.023$). All other comparisons, including ENCONT and the two experienced groups as well as comparisons between learner groups, were not significant ($p > 0.05$). Thus, it appears that L2 experience has a positive effect on L2 categorization, as only INEXP learners were found to differ significantly from English monolinguals.

3.2 Spanish task

The category boundaries for Spanish /p/-/b/ were calculated using the same procedure as in the case of English. The mean category boundaries for each group are shown in Fig. 1. Results in Spanish mimic those obtained in the English task; the learners' group with the highest VOT boundary value was EXP2 (11.2 ms), followed by INEXP (8.4 ms), while in

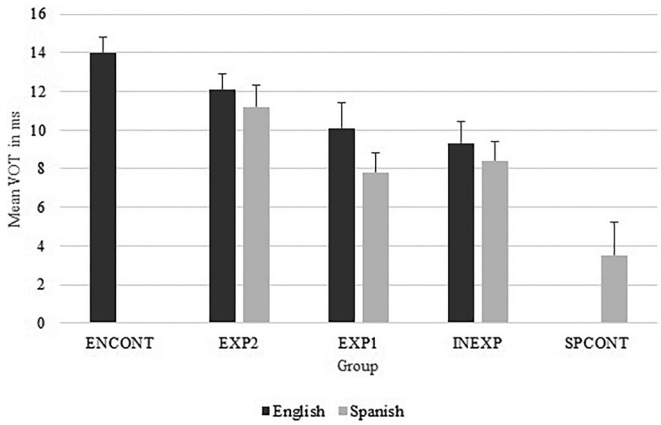

Fig. 1. English and Spanish /p/-/b/ mean boundaries (in ms) for all groups (ENCONT: English control group; EXP2: Spanish experienced learners of English living in the UK; EXP1: Spanish experienced learners of English living in Spain; INEXP: Spanish inexperienced learners of English living in Spain; SPCONT: Spanish control group) including standard error bars.

this case EXP1 presented the lowest values among the learners (7.8 ms). SPCONT were found to have the category boundary with the lowest VOT (3.5 ms).

In this case, the one-way ANOVA (independent variable: group; dependent variable: boundary), also yielded a significant effect of group [$F(3, 35) = 6.233$; $p = 0.002$]. *Post hoc* Bonferroni comparisons revealed significant differences between SPCONT and the most experienced group (EXP2) ($p = 0.001$). All other comparisons were not significant ($p > 0.05$). In short, this result suggests that the amount of L2 experience may affect the categorization of voiced and voiceless stops in L1.

3.3 Between languages comparison

In order to determine whether Spanish learners of English perceived the /p/-/b/ contrast differently in their L1 and L2, the category boundaries obtained by each participant in Spanish and English were compared. Numerically, all L2 speaker groups presented slightly higher values in English than in Spanish (see Fig. 1). However, EXP2 presented values closer to English monolinguals in both languages (EXP2: 12.1 ms in English, 11.2 ms in Spanish, ENCONT: 14 ms, SPCONT: 3.5 ms), whereas EXP1 and INEXP had intermediate values both in Spanish and in English (EXP1: 10.1 ms in Spanish, 7.8 ms in English, INEXP: 9.3 ms in English, 8.4 ms in Spanish).

The results of a paired samples *t*-test for each group (with boundary as the dependent variable and language as the independent variable) indicated that no group presented significantly different categories in Spanish and in English [EXP2: $t(8) = 1.118$, $p = 0.296$; EXP1: $t(9) = 1.290$, $p = 0.229$; INEXP: $t(9) = 0.775$, $p = 0.458$]. Therefore, the statistical results do not reveal the presence of separate /p/-/b/ perceptual categories in L1 and L2.

Next, we examined if the results for the two languages were correlated to see if participants were moving their L1 and L2 boundaries in the same direction (see Fig. 2). A one-tailed Pearson's correlation test including all Spanish learners of English was

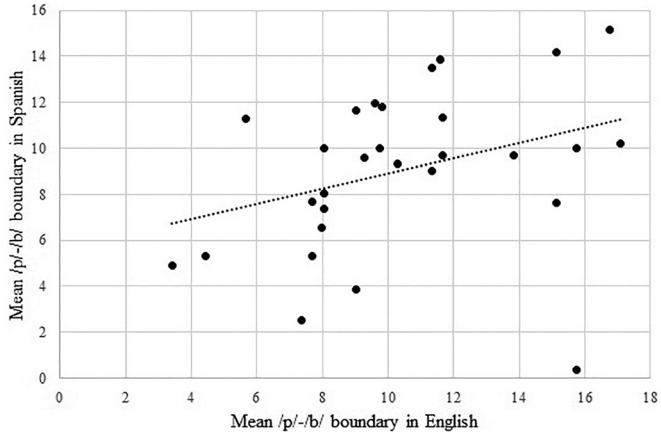

Fig. 2. Scatterplot illustrating all participants category boundaries in English (*x* axis) and in Spanish (*y* axis).

conducted and yielded a moderate yet significant correlation ($r = 0.341$, $N = 29$, $p = 0.035$). This result, taken together with the fact that none of the groups seemed to present separate L1 and L2 categories, suggests that Spanish learners of English might have moved their perception of stops, both in L1 and in L2, toward English-like values.

4. Discussion

The purpose of the present study was to examine the effect of L2 experience on L2 and L1 stop perception and to determine whether L2 learners of English differing in L2 experience had separate L1 and L2 /p/-/b/ categories or a shared single category. Although all groups had category boundaries with smaller VOT values than the ENCONTs, only INEXP presented a boundary (9.3 ms) that varied significantly from ENCONT (14 ms). The lack of a difference between the two more experienced groups and ENCONT indicates that L2 experience may bring about a more native-like categorization of L2 stops. Further, all groups, including the least experienced group, presented category boundaries with greater VOT values in Spanish than the Spanish monolinguals. This indicates that learning an L2 that makes a different use of VOT (such as in the case of Spanish learners of English) may modify L1 stop perception to a certain extent. However, only the group with the greatest amount of L2 experience (EXP2) differed significantly from SPCONTs, suggesting that intensive L2 experience may be necessary to affect L1 stop perception. Finally, changes in the perception of L2 and L1 appear to happen in the same direction, that is, toward a more L2-like perception.

These findings are in line with some previous studies which showed that a greater amount of L2 experience may result in a more accurate perception of L2 (e.g., Flege *et al.*, 1997; Gorba, 2018), as well as in a deviation in L1 perception toward L2 (e.g., Dimitrieva, 2019). Similar results have been reported for production; L2 experience has been found to cause a bidirectional effect on stop production, that is, an influence of L1 on L2, as well as an effect of L2 on L1 (e.g., Flege, 1987). However, the present study replicated only partially the results obtained in Gorba (2018), which reported a significant effect of L2 experience on L2 perception but failed to find any effect of L2 on L1. A plausible explanation could be that the experienced participants in Gorba (2018) had spent a shorter period of time in the L2 setting than the experienced group in the present study and were tested in an L1 setting. In other words, the experienced group studied in Gorba (2018) is comparable to the group with intermediate experience living in Spain presented in this study, which, in fact, did not differ significantly from SPCONTs.

All Spanish learners of English (regardless of the amount of L2 experience) seem to have a common L1 and L2 perceptual category for /p/-/b/, given that no significant differences were found in the categorization of L1 and L2 stops. This may be an example of category assimilation (Flege, 1995), as Spanish learners of English seem to use a single category for /p/ and /b/ presenting characteristics from both L1 and L2. The most experienced group presented L1 and L2 categories that were closer to native English speakers' values, whereas the group with a short experience, as well as the INEXP group, had L1 and L2 categories with intermediate values. Therefore, L2 experience (understood as length of residence in an immersion setting) has not been found to help create new L2 perceptual categories, but to modify the existing L1 category toward the L2.

All in all, this study suggests that a greater amount of L2 experience results in a more native-like perception of the stop voicing contrast in L2, and that it can also have an effect on the categorization of the L1 distinction, particularly for learners living in an L2 setting. All L2 speaker groups seemed to have a common L1-L2 category, that is, a single /p/ category and a single /b/ category for English and Spanish. Merged categories were found to present L1 and L2 characteristics to a greater or lesser extent depending on the amount of L2 experience. Participants tested in this study also completed a production experiment. However, due to space limitations, production data has not been included. Production results will be presented in future studies and will be compared to the perception results reported in this paper.

Acknowledgments

This research was supported by Project No. FFI2017-88016-P from the Spanish Ministry of Economy and Competitiveness and the research group Grant No. 2017SGR34 from the Catalan Government. The author would also like to thank the English Department at UAB for the Ph.D. Grant PIF and Esther de Leeuw for allowing me to use the phonetics lab at Queen Mary University of London.

References and links

[1]Slope was also explored as a measure by using the same analysis as for boundary, which is explained in the main text. However, no significant differences were found between groups and, thus, it has not been included in this paper for the sake of brevity.

Aliaga-García, C., and Mora, J. C. (**2009**). "Assessing the effects of phonetic training on L2 sound perception and production," in *Recent Research in Second Language Phonetics/Phonology: Perception and Production*, edited by M. A. Watkins, A. S. Rauber, and B. O. Baptista (Cambridge Scholars Publishing, Newcastle upon Tyne, UK), pp. 2–31.

Best, C. T., and Tyler, M. D. **(2007)**. "Nonnative and second-language speech perception: Commonalities and complementarities," in *Language Experience in Second Language Speech Learning: In Honor of James Flege*, edited by M. Munro and O.-S. Bohn (John Benjamins, Amsterdam), pp. 13–34.

Boersma, P., and Weenink, D. **(2016)**. "Praat: Doing phonetics by computer (version 5.3.56) [computer program]." http://www.praat.org/ (Last viewed May 2016).

Cabrelli, J., Luque, A., and Finestrat-Martínez, I. (**2019**). "Influence of L2 English phonotactics in L1 Brazilian Portuguese illusory vowel perception," J. Phonetics **73**, 55–69.

Carlson, M. T., Goldrick, M., Blasingame, M., and Fink, A. (**2016**). "Navigating conflicting phonotactic constraints in bilingual speech perception," Bilingualism **19**(5), 939–954.

Cebrian, J. (**2019**). "Perceptual assimilation of British English vowels to Spanish monophthongs and diphthongs," J. Acoust. Soc. Am. **145**(1), EL52–EL58.

Dimitrieva, O. (**2019**). "Transferring perceptual cue-weighting from second language into first language: Cues to voicing in Russian speakers of English," J. Phonetics **73**, 128–143.

Escudero P. (**2005**). "Linguistic perception and second language acquisition: Explaining the attainment of optimal phonological categorization," Ph.D. thesis, LOT Dissertation Series 113, Utrecht University.

Flege, J., Bohn, O-S., and Jang, S. (**1997**). "The effect of experience on nonnative subjects' production and perception of English vowels," J. Phonetics **25**, 437–470.

Flege, J. E. (**1987**). "The production of new and similar phones in a foreign language: Evidence for the effect of equivalence classification," J. Phonetics **15**, 47–65.

Flege, J. E. (**1995**). "Second language speech learning: Theory, findings and problems," in *Speech Perception and Linguistic Experience: Issues in Cross-language Research*, edited by W. Strange (York, Baltimore, MD), pp. 233–277.

Gorba, C. (**2018**). "The effect of L2 experience on the categorization of native and non-native stops by Spanish learners of English," in *Persistence and Resistance in English Studies. New Research*, edited by S. Martin, D. Owen, and E. Pladevall-Ballester (Cambridge Scholars Publishing, Newcastle upon Tyne, UK), pp. 163–173.

Hazan, V. L., and Boulakia, G. (**1993**). "Perception and production of a voicing contrast by French-English bilinguals," Lang. Speech **36**(1), 17–38.

Julià, J. (**1981**). "Estudi contrastiu dels oclusius de l'anglès i el català. Un experiment acústic" ("Contrastive study of English and Catalan obliques. An acoustic experiment"), Estudi General **1**(2), 75–85.

Levy, E. S., and Law, F. F. II (**2010**). "Production of French vowels by American-English learners of French: Language experience, consonantal context, and the perception-production relationship," J. Acoust. Soc. Am. **128**(3), 1290–1305.

Lisker, L., and Abramson, A. S. (**1964**). "A cross-language study of voicing in initial stops: Acoustical measurements," Word **20**(3), 384–422.

Riney, T. J., and Okamura, K. (**1999**). "Does bilingualism affect the first language?," ICU Lang. Res. Bull. **14**, 101–113.

Tice, M., and Woodly, M. (**2012**). "Paguettes and bastries: Novice French learners show shifts in native phoneme boundaries," UC Berkeley Phonology Lab Annual Report.

Williams, L. (**1977**). "The perception of stop consonant voicing by Spanish-English bilinguals," Percept. Psychophys. **21**(4), 289–297.