On the status of the phoneme /b/ in heritage speakers of Spanish

Rajiv Rao - University of Wisconsin-Madison
rgrao@wisc.edu

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Resum. Sobre l'estatus del fonema /b/ en els parlants d'herència de l'espanyol. Aquest estudi examina les produccions intervocàliques de /b/ per part de parlants d'herència de l'espanyol residents als Estats Units. Es van dividir un total d'onze parlants en dos grups en base al grau d'exposició a l'espanyol en l'entorn domèstic, i tots van completar unes tasques de lectura i descripció d'imatges dissenyades per tal d'obtenir la producció de /b/ intervocàlica mostrant variació en la posició dins de la paraula, l'accent sil·làbic i l'ortografia. Segons els resultats del model d'efectes mixtos, tots dos grups clarament van realitzar tres al·lòfons amb variació en mode d'articulació, però el grup amb més experiència domèstica amb l'espanyol va aplicar una regla fonològica d'espirantització a una aproximant pura amb més freqüència en totes les dades. Els al·lòfons aproximants tensos i oclusius menys similars a la producció meta apareixen més en la tasca de lectura, en síl·labes accentuades, i en el grup amb menys exposició a l'espanyol. D'altra banda, la posició dins de la paraula interactua amb el grup i la tasca per donar lloc a formes menys similars a la producció meta. Els resultats posen èmfasi en la influència del context lingüístic, l'ortografia, i la demanda cognitiva de les tasques a l'hora d'explicar la producció fonètica i fonològica dels parlants

Paraules clau: parlants d'herència, espirantització, espanyol, fonètica, fonologia.

Abstract. On the status of the phoneme /b/ in heritage speakers of Spanish. This study examined intervocalic productions of /b/ in heritage speakers of Spanish residing in the United States. Eleven speakers were divided into two groups based on at-home exposure to Spanish, and subsequently completed reading and picture description tasks eliciting productions of intervocalic /b/ showing variation in word position, syllable stress, and orthography. The mixed-effects results revealed that while both groups manifested three clear phonetic categories, the group with more at-home experience followed a phonological rule of spirantization to a pure approximant to

a higher degree across the data. The less-target-like stop and tense approximant allophones appeared more in the reading task, in stressed syllables, and in the less experienced group. Word boundary position interacted with group and task to induce less-target-like forms as well. The findings emphasize the influence of language background, linguistic context, orthography, and cognitive demands of tasks in accounting for heritage phonetics and phonology.

Keywords: heritage speakers, spirantization, Spanish, phonetics, phonology

1. Introduction

Heritage speakers (HS) in the United States are those who were raised in a household in which they were exposed to a non-English minority language (Valdés 2001). Years of schooling and interactions in an English-dominant society result in HS forming a very heterogeneous group as adults, including individuals ranging from those with native levels of proficiency in the heritage language (HL) to those that barely speak or understand it, but still feel a cultural association with it (Van Deusen-Scholl 2003). Regarding HS of Spanish, who comprise a significant portion of all HS in the United States, linguistic proficiency in their HL has been tied to experiences with and development of the language at home and in social networks, both before entering school and as adults (Rothman 2009, among others).

Scholars in the last few decades have carried out many in-depth, invaluable investigations on namely the morphosyntactic and lexical features of heritage Spanish (seminal works include Montrul 2012, Roca and Colombi 2003, among many others). However, the phonetics and phonology of heritage Spanish have been relatively understudied. This point is relevant to all HS, as affirmed by Polinsky and Kagan (2007), who state, "While instrumental studies targeting the phonetics of heritage speech are badly needed, virtually nothing is known about the nature of phonological representations in heritage speakers" (p. 378). In fact, even studies addressing second language (L2) Spanish phonology have urged the pursuit of heritage phonology. For example, Face and Menke's (2009) work on the spirantization of /b, d, g/ in L2 learners states that while their study excluded HS, the phonological system of such speakers merits future examination.

Inspired namely by commentary to this point, the current study carries out an acoustic analysis of /b/ in two groups of HS who are distinguished by past and present experiences with Spanish and English. This particular phoneme was selected due to its phonological and orthographic differences in Spanish and English. The results fill existing research gaps in heritage linguistics, while showing that allophonic realizations are influenced by an array of factors.

2. Literature review and current agenda

2.1. Characterization of /b/

In English, /b/ (voiced, bilabial, stop) and /v/ (voiced, labiodental, fricative) are separate phonemes, whereas in Spanish, /b/ is a phoneme with the same articulatory classification as in English, but <v> is a grapheme corresponding with /b/. Additionally, in Spanish, most clearly in intervocalic position, both word-internally and across word boundaries, /b/ weakens to [β], a spirantized allophone (e.g., *la baba* 'drool':/la baba/ → [la.'βa.βa]), which has been classified as an approximant by some (Hualde 2005, Martínez Celdrán 1984, 1991, 2004, among others) and a fricative by others (Quilis 1993, among others). Such weakening does not occur in English. Scholars believing that the allophone is an approximant have relied on acoustic analyses to demonstrate that it should not be considered a fricative because it does not exhibit the aperiodic energy, noise, lengthy duration, and relatively low intensity that characterize fricatives like /f, s, x/ (Hualde 2005, Martínez Celdrán 1984). In approximants, the distance between articulators is wide enough to prevent turbulent airflow, which, intervocalically, results in a continuous formant structure between adjacent vowels. As the distance between articulators increases, formant structure becomes clearer and periodic energy increases. However, approximants exhibit variation in distance between articulators (Hualde 2005, Martínez Celdrán 2004). Martínez Celdrán (1984, 1991) argued that a *pure approximant* (PA; [β]) is vowel-like, with a relatively wide opening between lax articulators, a lack of turbulence, and clear formants, while a *tense approximant* (TA; [b̞]) has more closure between articulators and does not demonstrate clear formants, but, crucially, does not produce the tension or closure required to create a stop burst or the turbulence of fricatives[1]. In general, PAs are the most frequently documented approximant realization in native Spanish speech, regardless of dialect. In terms of other allophones, it is worth noting that the only contexts in which /b/ is generally realized as the faithful, stop allophone [b] in Spanish are after a pause or a nasal consonant. Overall, it is clear that consonantal tension across manners of articulation is a gradient phenomenon that has an inverse relationship with intensity, and can be affected by syllabic stress and surrounding vowel height (Hualde 2005, Martínez Celdrán 1984).

2.2. Relevant heritage and L2 Spanish studies

Since the turn of the century, a series of studies that included stop consonants revealed that HS' childhood exposure (speaking and/or hearing) to Spanish led to

1. Martínez Celdrán (1984) uses [β˛] and [b˛] to refer to PAs and TAs, respectively. However, the open diacritic used for the TA in the current study is chosen in order to conform with the International Phonetic Alphabet.

significant phonetic (among other) benefits when compared to L2 learners (Au et al. 2002, 2008, Knightly et al. 2003, Oh and Au 2005). More recently, Amengual (2012) found that English cognates affect the voice onset time (VOT) of /p, t, k/, and Kim (2012) showed that HS are native-like in their perception but not production of Spanish stop consonants. In terms of vowels, Ronquest (2012) shed light on clear heritage versus native quality differences, which were affected by task type.

Adult L2 learners represent a distinct population from HS; however, for reasons related to methods and overarching acquisitional issues, a set of L2 studies on stop consonants is reviewed here. Face and Menke (2009) reported that years studying Spanish, phonological context (e.g., stressed/unstressed syllable and word-internal/word boundary), orthography, and task type all influenced the ability to spirantize voiced stops. Additionally, Díaz-Campos (2004, 2006) found minimal improvement in spirantization of intervocalic voiced stops regardless of L2 learners' experiences with Spanish. On the other hand, the intermediate speakers in González-Bueno (1995) demonstrated context-appropriate spirantization in approximately half of their voiced stops. Furthermore, Zampini (1994) attributed the non-target allophones of /b, d, g/ to transfer of English patterns, while also observing that <v>, and thus, the phoneme /v/, interfered with /b/ in reading tasks. Subsequently, Zampini (1998a) claimed that the acquisition of voiced stop spirantization is based on learner level and prosodic domain; lower levels of learners applied the rule below the prosodic word level, while more advanced learners were able to do so above this word level. Finally, Zampini's (1998b) work on the production and perception of VOT in bilabial stops evidenced better performance in the former task type than the latter.

2.3. Research questions

Motivated by the information presented in prior sections, the research questions of this study are two: (i) do HS with distinct present and past experiences with Spanish produce intervocalic /b/ differently?; (ii) does phonological context (i.e., syllable stress, word position), orthography (i.e., <b> versus <v>), and/or task type (i.e., reading versus unscripted) affect /b/ productions?

3. Methods

3.1. Participants

Eleven undergraduate HS were recruited to participate in a pair of data elicitation tasks. At the time, they were enrolled in a Spanish for HS course in which reading and writing were emphasized and control of pronunciation was assumed. First, they filled

out a language history questionnaire, as well as a pair of self-assessment surveys in which they evaluated their proficiency in English and Spanish and provided responses on a 1-5 scale to statements concerning their use of English and Spanish in the past and present. Scores on these pre-task measures led to the division of participants into two groups: Group 1 (G1; six speakers) and Group 2 (G2; 5 speakers)[2]. The main distinguishing features of each group are: G1 speakers assessed their proficiency in their two languages as being relatively balanced, had more experience with Spanish at home as children regardless of the age of relatives present, and continue to consistently use it at home as adults; G2 speakers rated their English skills as markedly higher, had more exposure to English as children, particularly through relatives similar in age, and use more English/ are more passive with Spanish when spending time with family nowadays. All individuals were between the ages of 18-24 at the time of participation, are of Mexican descent, and were either born in the United States or moved there prior to beginning school.

3.2. Materials

Intervocalic /b/ productions were elicited through a reading task and a picture description task. The former consisted of word lists and paragraphs taken from Morgan (2010), while the latter was administered through a Powerpoint presentation containing a series of slides, each of which had multiple images of objects containing at least one instance of /b/(see the Appendix for stimuli). Including various images on each slide allowed speakers to not only talk about each object individually, but also compare objects, which helped increase token counts. Every word containing intervocalic /b/, even if it was part of a description and not a specific stimulus, was selected for acoustic analysis. All recordings were carried out using Praat (Boersma and Weenink 2013), a head-mounted microphone, and a laptop.

3.3. Analysis

After all recordings were completed, acoustic and statistical analyses were done. Regarding the former, each realization of /b/ was categorized as 'PA,' 'TA,' 'stop' or 'fricative' based on spectrographic, waveform, duration, and intensity properties identified in Praat. Interestingly, across speakers, the analysis failed to reveal instances of fricatives. We will return to the importance of this point in the concluding section, but henceforth, the results of our analysis will center on PAs, TAs, and

2. The consistent spirantization of intervocalic /b/ to a PA in native Mexican Spanish in tasks similar to those from this study was confirmed prior to the collection of heritage data.

stops. Figure 1 displays the acoustic properties of the three allophones observed in the data, all of which were corroborated through comparison with Martínez Celdrán (1984). With respect to adjacent vowels, the PA in *sábado* ('Saturday') displays a continuous formant structure and a periodic waveform with only a slight decrease in amplitude. The segment measures just 44 milliseconds (ms) and is similar in intensity to its adjacent vowels. The stop in *la bodega* ('the winery') does not demonstrate activity in the spectrum or waveform, thus signaling articulatory closure which, in this case, measures 65 ms. Following this closure, we notice a clear burst indicative of stops. Also, the flanking vowels are drastically more intense than this stop. Finally, the TA in *una vela* ('a candle') fails to exhibit significant formant structure, does not illustrate spectrographic or waveform evidence typical of fricatives or stops, has a closure duration of 62 ms, and is less intense than each of its surrounding vowels.

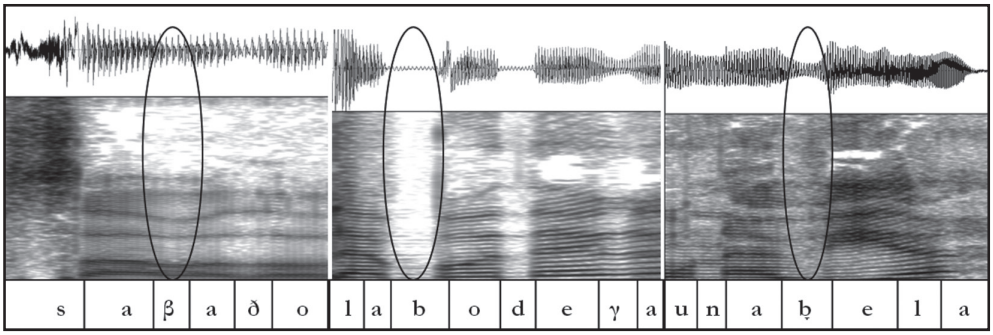

Figure 1. From left to right, realizations of a PA, a stop, and a TA.

Each /b/ token was also classified based on speaker group, task, orthography (in the picture task, this refers to how the word would be spelled), location in stressed/unstressed syllables, and word-internal/word boundary position. In terms of the statistical analysis, the acoustic data was subjected to a generalized linear mixed-effects model with a random effect for participant, which was run through R software (R Development Core Team 2008). Separate models for the three dependent variables (i.e., PA, TA, stop) were formed, each of which generated information on the significance (p=0.05 threshold) of the fixed effects (i.e., the independent variables of group, grapheme, stress, position in the word, and task) as well as potential interactions between these terms.

4. Results

A total of 2,245 tokens are discussed in this section. The distribution according to each independent variable is as follows: 1,305/G1, 940/G2; 1,497/reading task, 748/ picture task; 1,166/<b>, 1,079/<v>; 1,391/unstressed syllable, 854/stressed syllable; 1,346/word boundary, 899 word-internal. The speakers' overall token distribution is: 1,329 PAs, 503 TAs, and 413 stops. The two upcoming subsections first overview the main effect results for each model before moving on to significant interactions between terms (i.e., possible outcomes within each fixed effect). Within each subsection, a series of graphs incorporating the three manners of articulation illustrates the specific influences of each main effect or interaction terms. It should also be noted from the outset that the random effect of participant shows the most variance in the TA model and the least in the stop model; however, the contribution of this effect across models is very minor when compared to the fixed effects, and thus will not be discussed in depth[3].

4.1. Main effects

Table 1 outlines the results for the five main effects in each of the models. Interestingly, the set of significant effects is different in each model. The three effects on PAs are the stress condition, task, and speaker group. On the other hand, for TAs, speaker group, grapheme, and syllable stress are significant. Lastly, stops only demonstrate two main effects, which are task and syllable stress. At this point, position in the word appears to be insignificant across the board; however, we cannot eliminate it from the discussion of the data because it participates in some of the significant interactions addressed in the next subsection.

Figure 2 displays the outcomes of the group effect for each of the three manners of articulation. Based on Table 1, we know that the PA and TA categories are significantly influenced by group across the data. In the first case, G1 produces more target-like PAs, while in the second comparison, G2 favors higher rates of TAs. While raw calculations indicate that G2 more commonly articulates stops, an intergroup comparison does not achieve significance.

3. While the random effects appeared negligible, an examination of the Akaike information criterion (AIC) of the models confirmed the need to maintain these effects.

Table 1: Statistical outcomes of the five fixed effects in each of the three models run

Model	Fixed Effect	Standard Error	P
PA	Group	0.42	0.0004
	Task	0.23	0.0001
	Grapheme	0.21	0.20
	Stress	0.21	<0.0001
	Position	0.22	0.67
TA	Group	0.57	<0.0001
	Task	0.39	0.88
	Grapheme	0.36	<0.0001
	Stress	0.30	0.01
	Position	0.31	0.57
Stop	Group	0.40	0.21
	Task	0.30	<0.0001
	Grapheme	0.32	0.06
	Stress	0.28	0.0003
	Position	0.30	0.27

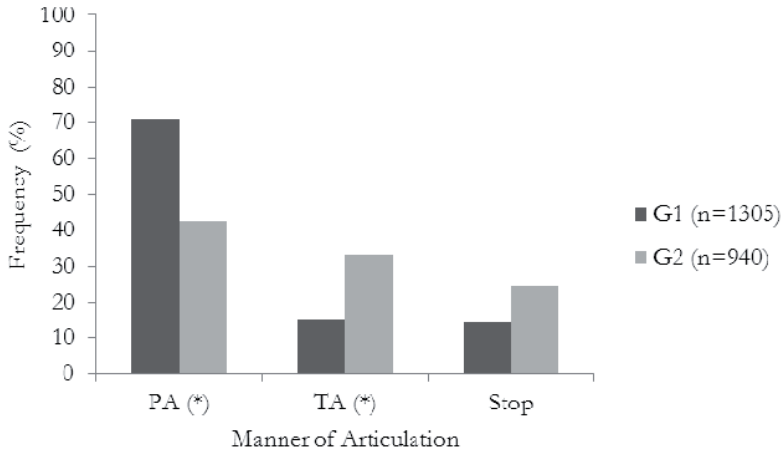

Figure 2. PA, TA, and stop realizations by group. The PA and TA differences are significant, as indicated by asterisks.

Manifestations of task effects on each manner of articulation are exhibited in Figure 3. In this case, we observe significant effects in PAs and stops, but not TAs, which is a distinct trend from the group effect. Here, we note that across all speakers, the picture task results in significantly higher rates of PAs. The increase in both TAs and stops in the reading task compensates for the lack of PAs; however, the latter intertask discrepancy is more noteworthy based on the statistical outputs.

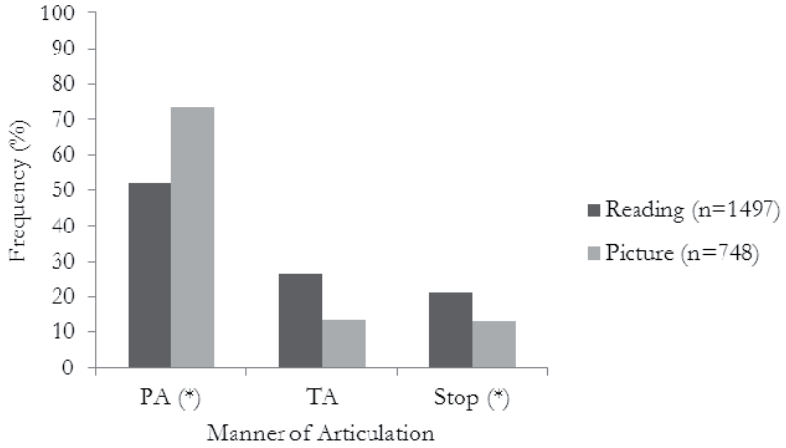

Figure 3. PA, TA, and stop realizations by task. The PA and stop differences are significant.

Next, in Figure 4, manner of articulation distributions are provided according to the graphemes corresponding with /b/. A comparison of the results for this main effect with the previous two reveals another distinct trend of significance. That is, the grapheme variable only has significant effects on TAs across speakers and tasks, which, as indicated by the middle set of bars, appears in the form of a drastic increase in instances of <v> rather than <b>. Conversely, PAs are produced similarly regardless of grapheme. Finally, while stops are superficially influenced by grapheme, their results are only marginally significant (p=0.06).

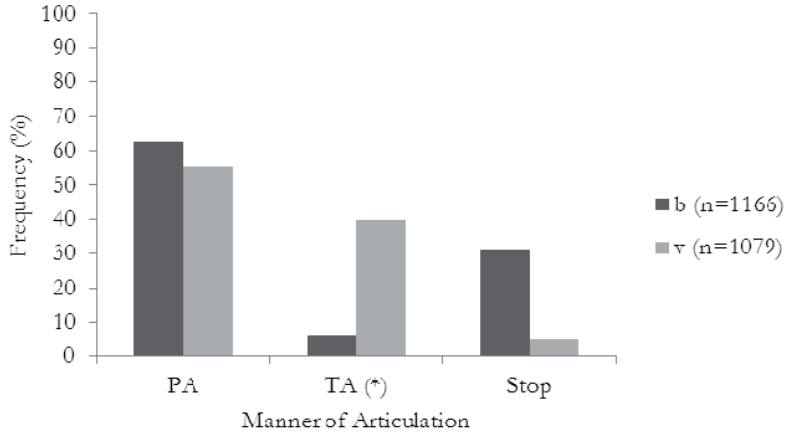

Figure 4. PA, TA, and stop realizations by grapheme. Only the TA difference is significant.

Figure 5 demonstrates the effect of syllable stress on /b/ articulations across the data. This main effect is the first we have observed whose contribution reaches significant levels in all three models. Regarding PAs, their occurrence is higher in unstressed syllables over stressed syllables. In opposing fashion, both TA and stop rates increase in stressed syllables versus unstressed syllables. While the comparisons within each manner may seem underwhelming upon first glance, the p-values in Table 1, particularly for PAs and stops, signal strong effects.

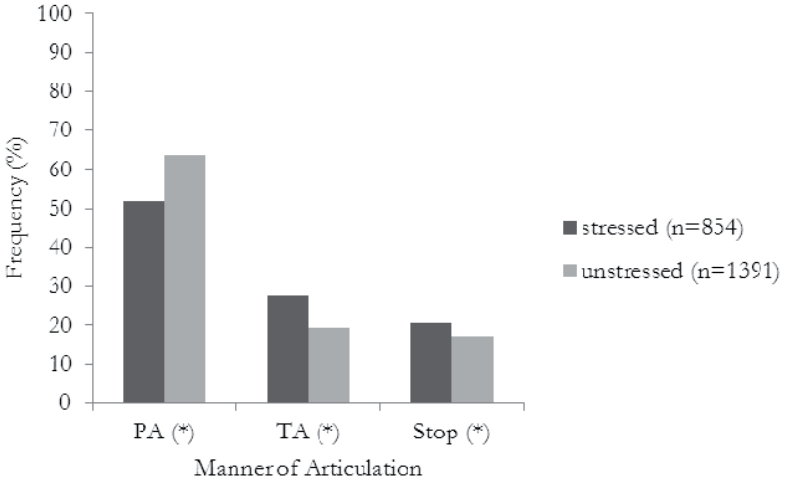

Figure 5. PA, TA, and stop realizations by syllable stress. There is a significant effect in all three models.

The last main effect is position of /b/ relative to word edges. This variable distinguishes itself from the previous four in that it does not significantly affect any of the three manners of articulation. Across the data, regardless of whether /b/ is at a boundary or word-internal, its manners of articulation are realized at relatively similar rates, as seen in Figure 6. However, as we will see in the following subsection, the contribution of this variable is clearly important when considering interactions.

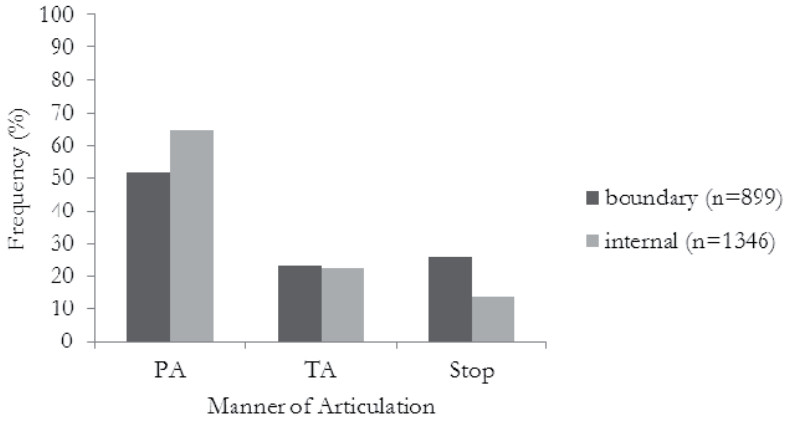

Figure 6. PA, TA, and stop realizations by position in the word. None of the three models contain significant effects.

4.2. Interactions

The significant interaction outputs generated by each model are provided in Table 2. Numerous combinations between terms are possible and were tested, but for the sake of precision, only those reaching significant levels are discussed here. The main observation to extract from Table 2 is that regardless of the model, the four terms that participate in significant interactions are: G2, word boundary, reading task, and the grapheme <v>. The difference between each model is the combinations of terms achieving significance. The three figures subsequent to this table illustrate and explain the contribution of interactions to their respective models.

Table 2: Statistically significant interaction terms in each of the three models

Model	Interaction	Standard Error	P
PA	G2*boundary	0.21	0.003
	Reading*boundary	0.23	<0.0001
TA	Reading*<v>	0.33	<0.0001
	Reading*boundary	0.30	0.03
Stop	G2*boundary	0.28	<0.0001

Figure 7 displays the interactions between G2*boundary and reading*boundary for PAs. In order to fully capture the modification incurred by the interaction between the two terms, it is helpful to include PAs' manifestation based on each individual term. First, looking at 'G2' and 'boundary' in isolation shows that PAs are produced at a rate of 42.7% in the former and 51.6% in the latter. However, when the terms interact, the frequency of PAs significantly reduces to 31.2%. The influence of the second interaction is similar. The realization rate of PAs in the reading task is 52.7%, which is almost identical to that of the word boundary condition. When the two terms interact, the PA rate dips to just 37.2%. Overall, this figure shows that in G2, in particular, and in the reading task, in general, location at a word boundary decreases the likelihood of PAs.

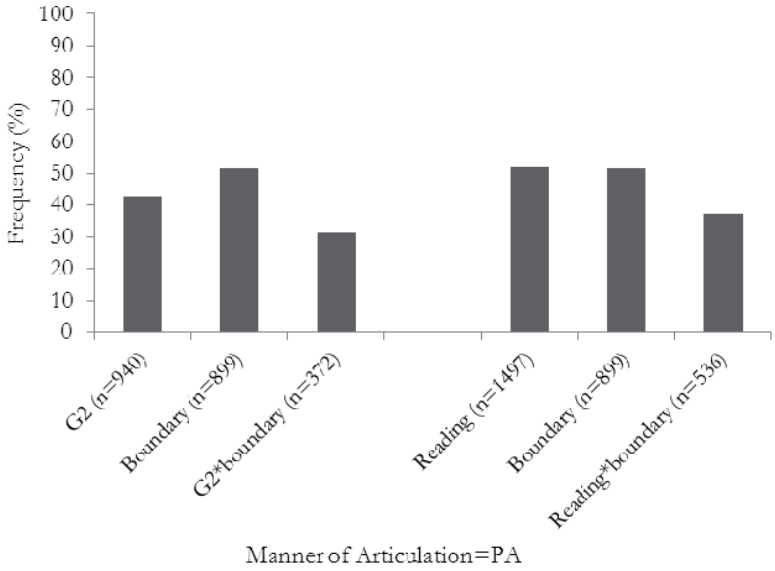

Figure 7. An illustration of the significant effect of two interactions on PAs.

Figure 8 presents the effects of the two significant interactions in the TA model. In the first one, where the reading task interacts with <v>, the TA frequency in the reading task alone is 26.7%, while that of just <v> is 39.7%. However, when the two terms interact, there is a significant boost in TA rate to 48.2%. A similar trend in the occurrence of TAs is seen in the interaction between the reading task and word boundaries. The isolated TA rates of 26.7% (reading task) and 22.9% (word boundary) increase to 29.3% when the two terms combine. This increase makes sense, especially when considering that the same interaction led to a decrease in PAs, as demonstrated in Figure 7.

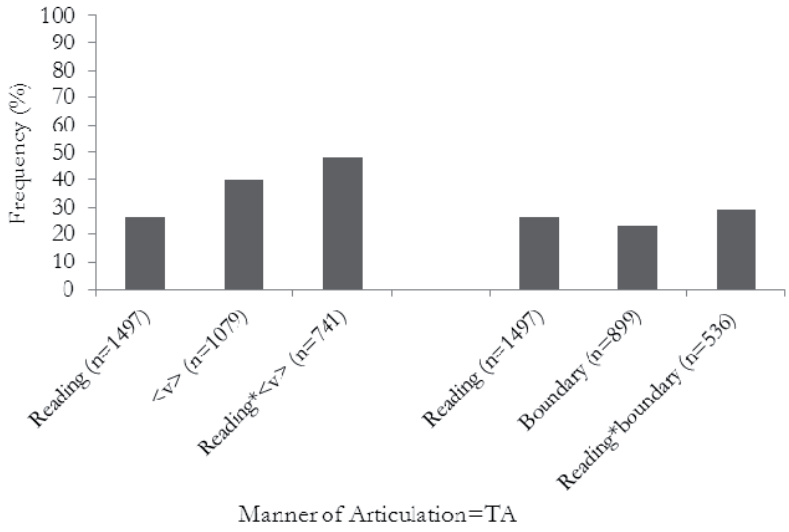

Figure 8. An illustration of the significant effect of two interactions on TAs.

Finally, Figure 9 depicts the effects of the significant interaction for stops, which specifically relates to G2. Individually, 24.3% of this group's realizations of /b/ are stops, while stops at word boundaries occur at a rate of 25.5%. The interaction of these two terms leads to a jump in stop production to 36.3%, which, after re-examining the identical interaction in Figure 7, is logical, since in the case of that interaction, PA realizations dropped.

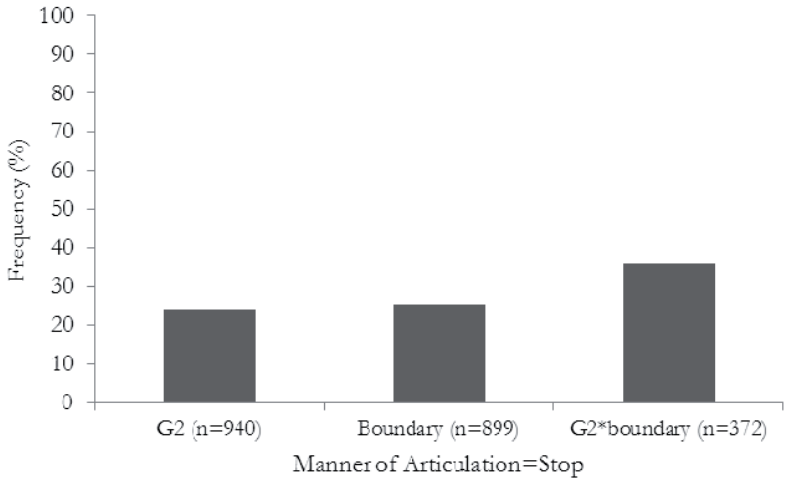

Figure 9. An illustration of the significant effect of an interaction on stops.

5. Discussion and conclusions

Recall that the main difference between our two HS groups dealt with past and present at-home experience with Spanish; G1 reported general exclusivity of Spanish, while G2 described a linguistically mixed past and an English-dominant present. When looking at the data as a whole, we found evidence of G1 possessing a production advantage in the form of significantly more target-like, weakened productions of intervocalic /b/ when compared to G2. G2 speakers compensated for their lower rates of weakening via increases in tenser, less-target-like allophones, but without exhibiting articulatory friction. As such, the 'group' main effect suggests that increased exposure to Spanish with family is one factor that facilitated the more consistent application of a HL phonological rule in the most target-like fashion. In particular, G1 speakers' use of Spanish as children with younger relatives (e.g., siblings/cousins) and their ability to continue to speak their minority language at home as adults seem to be crucial distinguishing factors. The implications discussed in the remainder of this section are mostly relevant to the findings from both groups, but are developed while assuming the general differences just outlined.

An important conclusion to draw from the overall results is that all variation appeared phonetic rather than phonological. The data contained three tension-based phonetic categories of /b/ (following Martínez Celdrán 1984). The absence of fricatives prevents us from convincingly positing that English /v/ interfered with realizations of /b/, as was the case in L2 studies incorporating /b/ (e.g., Face and Menke 2009, Zampini 1994, 1998a). Furthermore, the specific graphemic distinction of <b> versus <v> influenced

/b/'s allophonic distribution, particularly concerning less-target-like forms; <b> resulted in increased stop rates (while only reaching the fringe of significance), while <v> significantly boosted the appearance of TAs. The latter was apparent across the data, but at heightened levels in the reading task, where an interaction was discovered. However, these comments should not overshadow that the weakened, PAs were still the most frequent realization of both graphemes. In line with these comments on graphemes is the fact that our results demonstrated considerable task-based variation, with the reading task, or the presence of orthography, resulting in decreases in PAs and increases in stops. More specifically, the interaction effects revealed that the reading-task-based decrease in PAs was particularly salient at word boundaries, while TAs also showed an increase through the reading*boundary interaction. From a language processing perspective, comparing our <v> and reading task results to previous L2 work insinuates that even though our HS displayed effects leading to some less-target-like allophones, they were more effective at coping with the complexities involved with the presence of orthographic conventions, a focus on form, the need to combine recognition and production in one task (Jones et al. 2012), and the simultaneous activation of target and non-target phonologies (Costa et al. 2000) and orthographic systems (Dijkstra and Van Heuven 1998). That is, /b/ and /v/ were both active in our HS, but the results imply that they selected /b/, which was realized with tension-based variation, but not to the extent of clearly reflecting /v/. In sum, this discussion suggests support for studies claiming that HS have a phonological advantage over L2 learners (e.g., Au et al. 2002, 2008).

Returning to word boundaries, the specific interactions involving G2 merit additional commentary. This group manifested fewer PAs and more stops at boundaries across their data, regardless of the presence or absence of orthography. Through reference to prosodic domains, we can interpret the stop increase as domain-initial articulatory strengthening (Fougeron and Keating 1997), since word boundaries often represent edges of the prosodic word domain. Another way of interpreting these G2-specific results is inspired by Zampini (1998a), whose L2 speakers produced intervocalic spirantization at the highest rate word-internally, or below the prosodic word (i.e., foot), rather than at word edges, which requires reference to the prosodic word or even phrase level. As such, the current findings imply that while native speakers typically weaken /b/ intervocalically to a PA in general, regardless of position within a prosodic domain or in the prosodic hierarchy, G2 speakers have more difficulty producing a weakened allophone in positions promoting articulatory strengthening and at higher levels of the prosodic hierarchy.

Finally, the one main effect that did not appear in interactions was syllable stress. However, it was also the only main effect yielding significance in all three models, with stressed syllables, which are more metrically prominent than unstressed syllables (Hualde 2005), leading to fewer PAs and more TAs and stops. Coupling this finding, applicable to all speakers, with previous remarks on domain-initial strengthening allows us to generalize that our HS generated less-target-resembling, more tense forms in contexts with increased relative prominence. However, the fact that the boundary condition was

associated with a restricted set of conditions, namely G2 and orthography, suggests that out of the two relatively strong contexts, perhaps target-like productions are generally more difficult for HS to consistently articulate in stressed syllables.

In future extensions of this study, it would be useful to address issues such as cognates, word frequency/familiarity, adjacent vowels, and speech rate effects, which would increase the explanatory power of similar data sets. Such effects could have led to some of the infrequent, counter-intuitive results in our data (e.g., stops for <v>). Native English and Spanish perceptions of the gradient differences observed are also recommended. These suggestions should be tackled using a wider range of HS participants and either in a longitudinal or cross-generational fashion so that thoughts on attrition, incomplete acquisition or dialectal leveling can be explored (e.g., Nagy and Kochetov 2013). Finally, a more controlled way of examining orthographic effects on /b/ realizations that is encouraged is through homophones such as *tubo* ('tube')/*tuvo* ('he/she had') and *baca* ('roof rack')/*vaca* ('cow').

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Appendix: Target words in the picture task

1. *La b̲andera* ('the flag')
2. *La b̲eb̲é* ('the baby (feminine)')
3. *El pav̲o* ('the turkey')
4. *La v̲aca* ('the cow')
5. *El ab̲ogado* ('the lawyer (masculine)')

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