



Article Assessing Rhotic Production by Bilingual Spanish Speakers

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Abstract: Due to its articulatory precision, the Spanish rhotic system is generally acquired in late childhood by monolingually-raised (L1) Spanish speakers. Heritage speakers and second language (L2) learners, unlike L1 speakers, risk an incomplete acquisition of the rhotic system due to limited Spanish input and possible phonological interference from English. In order to examine the effects of age of onset of bilingualism and cross-linguistic influence on bilinguals' rhotic productions, twenty-four adult participants (six sequential bilingual heritage speakers, six simultaneous bilingual heritage speakers, six L1 Spanish speakers, six L2 Spanish learners) were audio recorded in a storytelling task and a picture naming task. The alveolar taps [r] and alveolar trills [r] produced in these tasks were examined according to duration of the rhotic sound and number of apical occlusions. Results showed that the sequential bilinguals, but not the simultaneous bilinguals or the L2 learners, patterned similarly to the L1 Spanish speakers in their production of taps and trills. Neither heritage group produced the English alveolar approximant [I]; the L2 learners, on the other hand, did produce [I] when speaking Spanish. The results of this study suggest that early language input can affect the production of sounds that are acquired in late childhood.

Keywords: heritage; Spanish; acoustic analysis; rhotics

1. Introduction

Monolingually-raised (L1) Spanish speakers acquire their language system "with optimal and continuous exposure to" Spanish (Benmamoun et al. 2013). This continuous exposure allows them to acquire their native sound system early in childhood, although some sounds are acquired later than others. The alveolar tap [r] and trill [r], for example, are two of the last sounds to be acquired in childhood and are generally mastered before age seven (Carballo and Mendoza 2000; Jimenez 1987; Kehoe 2018). Unlike monolingually-raised speakers, second language (L2) learners and heritage speakers acquire Spanish in a bilingual environment. L1 English L2 Spanish learners grow up in a monolingual English environment and begin to learn their second language after childhood. Bilingual heritage speakers of Spanish, or "members of a linguistic minority who grew up exposed to their home language and the majority language", often shift to an increased use of English and receive limited Spanish input once they start attending school (Montrul 2010; Montrul 2012a). It is important to note that heritage speakers are also L1 Spanish speakers, given that they acquire their heritage language since early childhood. Heritage speakers, however, do not grow up in a monolingual environment and must be examined separately in terms of their Spanish productions. Thus, for the purpose of this study, we will use the term "L1 Spanish speaker" to describe monolingually-raised L1 Spanish speakers with no exposure to English in early childhood and the term "heritage speaker" for bilingual English-Spanish speakers who acquired Spanish as their L1 and English either simultaneously or sequentially in childhood. Likely due to their early exposure to the two languages in childhood, bilingual heritage

speakers often demonstrate a perception of the heritage language that is comparable to that of L1 speakers; their degree of target-likeness in their productions, on the other hand, varies and depends on actual heritage language use (Boomershine 2013; Chang 2020; Chang et al. 2008, 2011; Godson 2004; Hyltenstam et al. 2009; Kim 2015, 2019; Lukyanchenko and Gor 2011; Pierce et al. 2014; Ronquest 2013). Reduced childhood input and possible phonetic transfer—or the presence of non-native phonetic elements from one language onto the other—may affect bilingual speakers' Spanish productions, as has previously been suggested in studies on Spanish, Mandarin, Western Armenian, Korean, and Arabic (Au et al. 2002; Chang et al. 2011; Elliott 1997; Face 2006, 2018; Godson 2004; Kim 2015, 2019; Knightly et al. 2003; Saddah 2011). This may be especially true of sounds that are acquired late in childhood and are articulatorily complex, such as the Spanish alveolar tap and trill.

While previous research has measured the production of the Spanish rhotic system by L1 speakers, L2 learners, and heritage speakers, no study has examined the effects of age of onset of bilingualism and cross-linguistic influence in phonology when comparing all speaker groups. To this effect, a storytelling task and a picture naming task were used to examine the production of Spanish rhotic sounds by adult heritage speakers who had been exposed to only Spanish until school-age (sequential bilinguals), heritage speakers who had been exposed to English and Spanish throughout childhood (simultaneous bilinguals), L2 learners who had acquired Spanish after childhood, and monolingually-raised L1 Spanish speakers.

1.1. The Production of Spanish Rhotics by L1 Spanish Speakers

Spanish has two rhotic sounds that appear in all varieties of the language: the alveolar tap [r] and alveolar trill [r]. The alveolar tap is produced with a single rapid contact of the tip of the tongue against the alveolar ridge and the alveolar trill is produced with multiple contacts between the tongue apex and the alveolar ridge. The number of apical constrictions required in order to produce an alveolar trill varies according to the source cited; Ladefoged and Maddieson (1996), for example, cite the alveolar trill as consisting of two to five periods of occlusion, while later work has suggested that this sound can be produced with two or three apical occlusions (Hammond 1999; Hualde 2005).

The Spanish rhotic system's articulatory complexity makes the alveolar tap and trill two of the last sounds to be acquired by L1 speakers in childhood. For example, Spanish-speaking children produce voiceless stop consonants /p/, /t/, and /k/ with adult-like accuracy before age four but the alveolar tap and trill are acquired by age 6;6 (Carballo and Mendoza 2000; Jimenez 1987; Kehoe 2018). This suggests that Spanish rhotics take longer to be fully acquired than other sounds in the Spanish sound inventory.

Likely due to their articulatory complexity, adult L1 Spanish speakers have been found to produce variations of the tap and trill. For example, Bradley and Willis (2012) recorded ten Veracruz Mexican Spanish speakers while describing a picture book. The Mexican Spanish speakers produced alveolar taps with full or approximant occlusions and alveolar trills produced with one or two apical contacts were common. Given these results, Bradley and Willis suggest that the alveolar tap and trill may be undergoing a neutralization in terms of the number of apical occlusions produced; that is, alveolar taps and trills may only be differentiated according to their duration rather than by number of apical occlusions. Similar results have been observed in Argentinian, Venezuelan, Andalusian, and Dominican Spanish (Colantoni 2006; Diaz-Campos 2008; Henriksen and Willis 2010; Willis 2006, 2007). Mexican Spanish speakers have also been found to produce fricative or assibilate variants of the Spanish rhotic sounds (Henriksen 2015; Hualde 2005; Lastra and Butragueño 2006).

1.2. The Production of English Rhotics by L1 English Speakers

Unlike the Spanish rhotic system, American English has one rhotic sound: the alveolar approximant [I]. This rhotic is characterized by a low F3 value (<2000 Hz), often approaching or merging with the F2 (Espy-Wilson 2004; Espy-Wilson et al. 2000; McGowan et al. 2004). The alveolar approximant is highly variable and has been categorized as having three to six different articulations. Commonly shared characteristics between these articulations include a constriction along the palatal vault, the lips,

and the pharynx (Delattre and Freeman 1968; Espy-Wilson et al. 2000; McAllister Byun et al. 2014; Zhou et al. 2008).

Although the American English rhotic system has only one sound, the alveolar [r] is also present in the language. The English flap and the Spanish tap are nearly identical, in that they are both produced with a rapid movement of the tongue tip or tongue blade against the alveolar ridge (Face 2006; Hualde 2005; Kim and Puigdelliura 2019; Rose 2010). The main difference between the English flap and the Spanish tap is their phonological distribution; the English flap is an allophone of the alveolar stops /t/ and /d/ that become an alveolar flap when they occur intervocalically after a stressed syllable, such as in *ladder* and *better* (Daidone and Darcy 2014; Face 2006, 2018; Kim and Puigdelliura 2019; Olsen 2012, 2016). The Spanish tap is not an allophone, but its own phoneme, and is not conditioned by syllable stress (Face 2006; Kim and Puigdelliura 2019). Thus, although American English speakers already have the alveolar flap in their native sound system, they do not associate this sound with a rhotic and require a re-categorization of their sound system when learning Spanish (Face 2006).

The alveolar [r] can be considered a completely new sound to L2 Spanish learners. However, its articulatory complexity makes it physiologically difficult to produce (Face 2006, 2018). In order to produce an alveolar trill, a "speaker must position the tongue and apply the correct amount of pressure against the alveolar ridge to allow oropharyngeal force to overcome occlusion while maintaining the ability for the tongue to recoil" (Olsen 2016). Because of the difficulty in producing this sound, L2 Spanish learners have been cited as overgeneralizing the alveolar tap in contexts that required the alveolar trill or increasing rhotic duration in lieu of producing multiple occlusions (Face 2006, 2018).

Due to the differences in the phonological distribution of the Spanish tap and the English flap, as well as the articulatory complexity of the Spanish trill, a growing number of studies have examined the production of the Spanish tap and trill by L2 learners. For example, Face (2006) recorded the production of Spanish rhotics by intermediate and advanced L2 Spanish learners while reading a short story. An acoustic analysis of the participants' audio files showed that the advanced learners were more accurate overall in their production of the alveolar tap and trill. Furthermore, the L2 learners were found to replace the alveolar tap with the English alveolar approximant and to overgeneralize the alveolar tap in contexts that required the alveolar trill. Other studies have also found learners that have more experience with Spanish to produce target-like rhotics (Face 2018; Olsen 2012, 2016). In other words, higher proficiency may aid L2 learners in re-categorizing the English flap as a Spanish tap and producing the articulatorily-difficult alveolar trill.

1.3. The Production of Spanish Rhotics by Heritage Speakers

Unlike L1 Spanish speakers or L2 learners, heritage speakers grow up exposed to both their home language (Spanish) and the majority language (English). Many heritage speakers achieve "partial command of the [heritage] language, short of native speaker level", despite receiving limited Spanish input throughout childhood (Montrul 2010). Although heritage speakers have been described as sounding native-like, recent research suggests that their production lies somewhere between that of an L1 speaker and an L2 learner (Benmamoun et al. 2013). Heritage speakers of Spanish who have receptive knowledge of Spanish have been found to significantly outperform L2 Spanish learners in their production of the heritage language (Au et al. 2002). Despite this result, many heritage speakers do not match the productions of monolingually-raised speakers. For example, Chang et al. (2008) compared the production of vowel contrasts and laryngeal contrasts (voiced vs. aspirated stop consonants) in L1 speakers of Mandarin, heritage speakers of Mandarin, and L1 English L2 Mandarin learners. The results of the vowel and laryngeal analyses showed that heritage speakers performed similarly to each L1 speaker group in their respective language; that is, the heritage speakers correctly distinguished phonemic categories between Mandarin and English. However, the heritage speakers did not articulate these categories in the same way as the L1 speakers of Mandarin. The heritage speakers produced Mandarin phonemes more natively than the L2 Mandarin speakers, but not as natively as the L1 Mandarin speakers. Similar results have been found in other studies on heritage

speakers of Mandarin, as well as in research focusing on heritage speakers of Western Armenian, Korean, and Spanish (Chang et al. 2011; Godson 2004; Kim 2015, 2019; Ronquest 2013).

The production differences between monolingually-raised L1 speakers and bilingual heritage speakers in the heritage language may be due to effects of cross-linguistic influence, modulated by age of onset of bilingualism. Some bilingual heritage speakers are simultaneous bilinguals, meaning that they were exposed to both the heritage language and the majority language since birth. Other heritage speakers are sequential bilinguals who spoke the minority or heritage language exclusively until starting school (Montrul 2010). It is important to clarify that L2 Spanish learners are also bilingual speakers but acquired English as a L1 in early childhood and Spanish as a L2 after childhood. This distinction is especially important when discussing sounds acquired late in childhood, given that insufficient input in childhood can compromise the development of the heritage language; indeed, Goldstein et al. (2005) found this result in their analysis of Spanish heritage speakers. They compared the phonological skills of predominantly English-speaking, predominantly Spanish-speaking, and equally-balanced Spanish-English bilingual children. All children were early English-Spanish bilingual heritage speakers living in the United States who varied in terms of their daily exposure to either language. When asked to name images in Spanish tap and trill than the bilingual speakers.

The possible effects of language transfer on bilinguals' productions are theorized in the Speech Learning Model, or SLM (Flege 1991, 1995, 2007; Flege and Bohn 2020). According to this model, the phonetic elements of two language systems exist in one common phonetic space, suggesting that they can mutually influence each other. Furthermore, the "greater the perceived phonetic dissimilarity between an L2 sound and the closest L1 sound, the more likely it is that phonetic differences between the two sounds will be discerned" (Flege 1995). In other words, bilinguals are more likely to acquire a sound in the L2 if it is "new" or different than a sound in the L1; vice versa, they are less likely to acquire this L2 sound if it is similar but not identical to a sound that already exists in the L1. In order to differentiate between sounds in the L1 and L2, bilinguals are hypothesized to first use L1 sounds as "substitutes" for the L2 sounds, which can potentially interfere or block the formation of new phonetic categories for L2 sounds (Flege and Bohn 2020). As bilinguals gain experience from the L2 in their daily life and accumulate detailed phonetic information, they are expected to gradually differentiate the L1 and L2 sounds. As bilingual heritage speakers with more exposure to the heritage language develop the categories of their L1, they are expected to differentiate between the sounds of the L1 and L2, even when these are similar. L2 learners, however, may fail to differentiate between similar sounds in their L1 and L2, leading to an "assimilation" of two similar sounds into one phonetic category (Flege 2007).

Previous studies have implemented the SLM to test the production of similar and novel sounds by bilingual heritage speakers and L2 learners. Flege (1991), for example, tested whether Spanish-English bilingual heritage speakers and L1 Spanish L2 English learners would be able to differentiate the Spanish /d/ and English /t/ according to voice-onset time. Based on the SLM, Flege predicted that children who had been exposed to English in childhood would establish separate phonetic categories for the English and Spanish stop consonants, while L2 English learners would not add an additional phonetic category for the "similar" English /t/. The results of the study's production task showed that both participant groups performed similarly to monolingual Spanish speakers in their production of the Spanish /d/, while only the bilingual heritage speakers performed similarly to the monolingual English speakers' productions of English /t/. In other words, the bilingual heritage speakers demonstrated a successful categorization of two similar sounds, while the L2 English learners were not able to note the phonetic differences between them.

Despite representing two sounds that are acquired late in childhood, are articulatorily complex, and risk phonetic assimilation by bilinguals, few studies have examined the Spanish rhotic system of heritage speakers. One of the first to do so was Henriksen (2015), who compared L1 speakers and bilingual heritage speakers of Mexican Spanish while narrating a picture book. Intervocalic taps and

trills produced in the storytelling task were analyzed according to duration and number of apical occlusions. Results showed that the L1 Spanish speakers and the heritage speakers patterned similarly in their production of the alveolar tap and trill; that is, both groups contrasted between the two rhotic sounds in terms of duration but not number of occlusions. This result patterns with previously recorded rhotic production of monolingual Spanish speakers (Bradley and Willis 2012; Henriksen and Willis 2010). However, the participants' language background questionnaire responses suggest that the heritage speakers were sequential bilinguals. Including only sequential bilinguals in the experiment may have skewed the results of the production study and have failed to reflect the heterogeneity that heritage speakers represent.

Like Henriksen (2015), O'Rourke and Potowski (2016) examined the production of the alveolar trill by bilingual heritage speakers in the Chicagoland area who were Mexican, Puerto Rican, or had both Mexican and Puerto Rican parents (MexiRican). The Puerto Rican heritage speakers produced a velarized trill overall, a characteristic of Puerto Rican Spanish, while the Mexican and MexiRican heritage speakers produced the alveolar trill in almost all cases. Similarly, Kim and Puigdelliura (2019) reviewed the production of the alveolar tap by bilingual heritage speakers of Mexican Spanish according to proficiency, language use, and language input. The participants were prompted to produce the Spanish alveolar tap via a drawing dictation task and their results showed that heritage speakers who spoke or were addressed in Spanish by older-generation speakers produced Spanish taps with higher lingual constriction rates. Despite assessing the production of the Spanish alveolar tap and trill, neither study compared heritage speakers' productions to L1 speakers or L2 learners.

Finally, Kissling (2018) compared the Spanish rhotic production of L1 Spanish speakers, bilingual heritage speakers, and L2 Spanish learners in Richmond, Virginia. The L1 Spanish speakers and heritage speakers tested in this study were from Mexico and El Salvador. The rhotic sounds produced in participants' audio recordings were measured according to duration and number of apical occlusions. The results of the acoustic analysis showed that the L1 Spanish speakers and the heritage speakers produced the alveolar tap and trill similarly, while the L2 learners produced more noncanonical rhotics than the other groups. In a post-hoc analysis, Kissling separated the heritage participants according to language dominance and found the English-dominant heritage speakers. Despite finding significant differences between English- and Spanish-dominant speakers, language dominance may not provide enough information to determine whether a heritage speaker fully acquired the rhotic sound system in childhood.

Though the focus of this study is not to examine the English productions of English-Spanish bilinguals, it is necessary to consider both the L1 and L2 productions of bilingual speakers to determine the effects of language contact on their speech (Grosjean 2008). No current study has examined the production of the English alveolar approximant by adult bilingual heritage speakers. Rather, limited research has focused on the acquisition of this phoneme by young English-Spanish bilinguals. One such study analyzed the speech of heritage speakers ages 3;1 to 3;10 and found these children to make substitutions of [I] with the glide [w] (Gildersleeve-Neumann et al. 2008). Although not focusing on heritage speakers but L2 Spanish learners, Olsen (2012, 2016) measured the production of the American English alveolar approximant. However, the purpose of this measurement was to determine how the shape of the rhotic would affect alveolar tap and trill articulations. There is currently a gap in our understanding of the bilingual nature of heritage speakers, specifically, in their performance of the majority language and their production of the English /I/.

Although the studies presented above review the production of the Spanish rhotic system by heritage speakers in some way, none include age of onset of bilingualism and cross-linguistic influence as factors in their analysis when examining the production of both the alveolar tap and trill. Additionally, only one study compared bilingual heritage speakers to L2 learners and L1 speakers. Bilingual heritage speakers acquire two languages in childhood; this has an especially strong effect on the acquisition of a language's phonology because of children's sensitivity to acoustic cues and the early development of neuromuscular articulators (Flege 2007; Kuhl et al. 2006, 2008; Patkowski 1990; Scovel 2000; Werker et al. 1981; Werker and Tees 1983, 1984, 1999). Due to its effect on the phonology of heritage speakers and L2 learners, language input may play a crucial role in the successful acquisition of the Spanish alveolar tap and trill. Furthermore, insufficient or qualitatively different input may lead to phonological transfer from the English rhotic system. In order to determine the effect of childhood Spanish input on rhotic production, the current study examined the production of the Spanish alveolar tap and trill by adult simultaneous bilingual heritage speakers, sequential bilingual heritage speakers, L1 Spanish speakers, and L2 Spanish learners.

1.4. The Present Study

In order to examine the influence of childhood language input on the production of the Spanish alveolar tap and trill by adult heritage speakers of Spanish, as well as compare their productions to L2 Spanish learners who did not acquire Spanish in childhood, three research questions were presented:

- 1. Do simultaneous bilingual heritage speakers of Spanish and sequential bilingual heritage speakers of Spanish pattern differently from each other and from L1 Spanish speakers in terms of their production of the alveolar tap and trill?
- 2. If differences in the production of the alveolar tap and trill by heritage speakers of Spanish are found, is there evidence of transfer of the English alveolar approximant onto the Spanish rhotic system?
- 3. Do L2 Spanish learners pattern differently from simultaneous bilingual heritage speakers of Spanish and sequential bilingual heritage speakers of Spanish in terms of their productions of these phonemes?

Based on the three research questions, three predictions were made. The first prediction anticipated that the sequential bilinguals would produce more target-like productions of the alveolar tap and trill than the simultaneous bilinguals. While sequential bilinguals experience a period of monolingualism in the heritage language in childhood, simultaneous bilinguals have no monolingual experience and speak both the majority language and the heritage language in childhood. Thus, it is possible that the simultaneous bilinguals did not receive enough Spanish input to fully acquire the L1 categories of articulatorily-complex and late-acquired sounds, like the Spanish rhotics. This prediction is supported by previous research; predominantly Spanish-speaking bilinguals have been found to produce more accurate articulations of the alveolar tap and trill than equally-balanced Spanish-English bilinguals (Goldstein et al. 2005).

The second prediction anticipated that neither heritage speaker group would transfer the English alveolar approximant onto the Spanish alveolar tap or trill. The SLM outlines the reorganization of bilinguals' phonetic categories during L2 acquisition. Because bilingual speakers are expected to relate the L2 sounds to L1 phonetic categories, we do not expect phonetic transfer from the L2 (English) onto the L1 (Spanish). Furthermore, no previous study on heritage rhotic productions has reported English transfer onto the Spanish rhotic system (Henriksen 2015; Kissling 2018; O'Rourke and Potowski 2016). Thus, neither bilingual heritage speaker group was expected to use the alveolar approximant when speaking Spanish. However, we anticipated that the simultaneous bilinguals (who were exposed to English since birth) would pattern more similarly to native English speakers in their production of the English rhotic than sequential bilinguals (who received less L2 input in childhood). Although the production of the L2 is not the focus of the current study, the results of previously collected English data produced by the same heritage speakers who participated in this study will be briefly discussed in the results and discussion sections.

The third prediction anticipated that the L2 Spanish learners would produce less target-like Spanish rhotics than the heritage speakers. Although the alveolar tap does exist in the English sound system as an allophone of /t/ and /d/, American English speakers do not recognize this sound as

a rhotic and L2 Spanish learners must re-categorize their English sound system in order to sound target-like in Spanish. In detailing the L1 and L2 outcomes necessary to create separate L2 phonetic categories, Flege and Bohn (2020) highlight that pre-existing L1 phonetic categories (such as the alveolar approximant) may interfere with or sometimes block the formation of new phonetic categories for L2 sounds. Based on previous studies examining L2 Spanish speakers' rhotic productions, we predicted that L2 learners would not re-categorize their sound system but would instead replace the Spanish tap with the English alveolar approximant [I] (Face 2006, 2018). As for the alveolar trill, the SLM posits that new or different sounds from those in the L1 will be more easily acquired by all L2 learners (Flege 1995, 2007). However, the trill's articulatory complexity makes it physiologically difficult to produce and higher proficiency is required in order to reach a target-like pronunciation (Face 2006, 2018; Olsen 2012, 2016). It is possible that L2 Spanish learners may attempt to produce the multiple occlusions necessary for an alveolar trill but fail to produce more than one occlusion, thus mimicking the production of the alveolar tap. Due to this pronunciation difficulty, it was expected that the L2 learners would overgeneralize the alveolar tap in contexts requiring the alveolar trill.

2. Method

2.1. Participants

Twenty-four adult participants were divided into four participant groups, based on their age of onset of bilingualism. Six participants were sequential bilingual heritage speakers of Mexican Spanish who had acquired Spanish at home and English at school. The sequential bilinguals reported acquiring Spanish since birth and started acquiring English at an average age of six. Six participants were simultaneous bilingual heritage speakers of Mexican Spanish who reported acquiring Spanish at home and English by 1;8 years of age. Both heritage groups were from the Chicagoland area and had high-intermediate to high-advanced Spanish proficiency. According to the Bilingual Language Profile, all but two participants were English-dominant speakers; one of the Spanish-dominant speakers was a sequential bilingual and the other was a simultaneous bilingual (Birdsong et al. 2012).

In addition, six L1 English L2 Spanish learners and six L1 Spanish speakers participated in the study. The L2 Spanish learners were from the Chicagoland area. They had acquired Spanish in an academic setting and were enrolled in upper-level Spanish courses at the time of testing. Despite their upper-level enrollment, only one L2 Spanish participant scored a proficiency score higher than high-beginner. All L2 Spanish learners were English dominant. The L1 speakers of Spanish had lived in Mexico until adulthood and had acquired Spanish since birth. All L1 speakers spoke English as an L2 and were Spanish dominant.

2.2. Materials

Three picture books were used to elicit Spanish and English rhotic productions in a storytelling task (Mayer 1967, 1969, 1974). Only the Spanish rhotic data is reported in this study, although a brief description of the English rhotic productions will be provided in the discussion. The books did not include any text, which allowed the participants to narrate the stories freely. Select lexical items containing intervocalic alveolar taps and trills were expected to be repeated throughout the narration, such as *mesero* 'waiter' and *perro* 'dog'.

In addition to the storytelling task, participants also completed a picture naming task. Participants were shown forty-six images representing disyllabic words, of which sixteen included an intervocalic rhotic sound. The picture naming task was included in order to ensure that the participants produced enough examples of the alveolar tap and trill. A list of the target words can be found in Appendix A.

2.3. Procedure

Participants were tested in one experimental session in a laboratory equipped with a sound-attenuating booth or in a quiet room with no distractions. All subjects gave their informed

consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Institutional Review Board (#19688). The participants first completed the Bilingual Language Profile, an instrument used to assess language dominance via self-reports (Birdsong et al. 2012). Following the Bilingual Language Profile, the participants were asked to sit in a sound booth or in a quiet room with no distractions to complete the storytelling task. They were given a physical copy of one of Mayer's picture books and were asked to narrate the images as if they were telling the story to a small child. The L1 Spanish speakers only narrated Mayer (1969) in Spanish. Half of the bilingual speakers narrated Mayer (1967) in English and the other half narrated Mayer (1969) in Spanish.

Following the storytelling task, the participants were asked to complete a picture naming task. The participants were given a series of printed images and were asked to describe what they saw in Spanish. Once the participants had completed the storytelling task and the picture naming task, all bilingual participants completed a modified version of the Diploma of Spanish as a Foreign Language (DELE) to measure their language proficiency (Montrul 2012b). This fifty-item test included a multiple-choice section focused on grammar and vocabulary and a cloze test. The L1 Spanish speakers were not required to complete the proficiency test.

Afterwards, the participants were asked to once again sit in the sound booth or quiet room and narrate a second book. Those who had narrated Mayer (1969) in Spanish narrated Mayer (1974) in English. The participants who narrated Mayer (1967) in English narrated Mayer (1969) in Spanish. This was done to ensure minimal influence from transitioning from one language to another. Overall, the L1 speakers of Spanish each took approximately twenty-five minutes to complete all tasks and the remaining three participant groups took approximately fifty minutes to complete the tasks.

2.4. Analysis

The participants were recorded using a TASCAM DR-05 96k/24-bit Portable Stereo Recorder and a Sony ECM-CS3 Omnidirectional Stereo Microphone. The recordings were transcribed and force-aligned using Praat and EasyAlign (Boersma and Weenink 2009; Goldman 2011). Only words containing an intervocalic alveolar tap or trill were considered for analysis; word-initial rhotics and rhotics in consonant clusters were not included in the analysis.

Productions of the intervocalic alveolar tap or trill were categorized into one of four conditions: only tap, only trill, contrast tap, and contrast trill. This categorization is based on the distribution of rhotic sounds in Spanish; the production of the alveolar tap and trill is distributed so that, in some positions, these sounds are contrastive, while in others, they are not. While the tap and trill are contrastive in intervocalic contexts (*caro* 'expensive'—*carro* 'car'), there are cases where only an alveolar tap (*mesero* 'waiter') or an alveolar trill (*arroz* 'rice') is expected to be produced. In other words, the categories "only tap" and "only trill" are non-contrastive.

EasyAlign was used to automatically segment the duration of each rhotic sound in the transcribed recordings. As for the apical occlusions, Henriksen (2015) used a categorization system to label each phonemic tap based on its degree of apical constriction (true tap, approximant tap, perceptual tap).

A true tap is defined as an occlusion with a clear break in the spectrogram, while an approximant occlusion demonstrates a reduction in the waveform and a lack of a clear occlusion (Figure 1). A perceptual tap (Figure 2a) lacks a clear occlusion or change from the surrounding vowels but often seems perceptible to the ear (Bradley and Willis 2012). In addition to Henriksen's three-category system, fricative and assibilate rhotics were also included in the analysis (Figure 2b). Previous research has found L1 speakers of Mexican Spanish to produce alveolar trills with fricative or assibilate characteristics (Henriksen 2015; Hualde 2005; Lastra and Butragueño 2006). These two rhotic types were marked as having no occlusion. For the purpose of this study, true or full taps and approximant taps were marked as having one or more occlusions given that there is a reduction in the waveform. Perceptual taps, fricative rhotics, assibilate rhotics, and the English alveolar approximant were marked as having zero occlusions or reductions in the waveform.



Figure 1. Intervocalic phonemic trill containing (**a**) two true apical occlusions for *perro* 'dog' and (**b**) two approximant apical occlusions for *perro* 'dog'.

Figure 2. Intervocalic phonemic tap and trill containing (**a**) a perceptual apical occlusion for *para* 'for' and (**b**) an assibilate apical occlusion for *tierra* 'earth'.

The twenty-four participants produced a total of 1387 Spanish rhotic tokens in both the storytelling task and the picture naming task. The Spanish rhotics produced in the storytelling task and picture naming task were analyzed together because both tasks examined participants' semi-spontaneous productions of Spanish rhotics. Of these tokens, the L1 Spanish speakers and both heritage participant groups produced no examples of the alveolar approximant. The data was tested for normality using the Shapiro-Wilk function in R for both rhotic duration and number of apical occlusions (Shapiro and Wilk 1965; R Core Team 2013). The duration data was found to be normally distributed but the occlusion data was not, so outliers 2.5 standard deviations from the mean were removed from the original dataset and data for both duration and number of apical occlusions was normalized using z-score values. The means and standard deviation values for each participant group can be found in Table 1.

In a separate study conducted to examine English-Spanish bilinguals' productions of the American English alveolar approximant [I], the rhotics produced by L1 English speakers, simultaneous bilinguals, and sequential bilinguals were examined according to F3 and F3-F2 values. Results of two linear mixed effects models showed that the simultaneous bilinguals patterned more similarly to the L1 English speakers in terms of their F3 and F3-F2 values than the sequential bilinguals. In other words, those bilinguals with some exposure to English in early childhood patterned more similarly to L1 English speakers in their production of the English rhotic than the sequential bilinguals who had had no exposure to English until later childhood.

	Mean (Standard Deviation)				
Participant Group	Only Tap Duration (ms)	Only Trill Duration (ms)	Contrast Tap Duration (ms)	Contrast Trill Duration (ms)	
L1 Spanish	29.7 (9.7)	69.8 (25.6)	28.6 (7.6)	66.5 (27)	
L2 Spanish	40.5 (25.6)	49.2 (24.8)	43.7 (29.7)	62.6 (29.9)	
Heritage Sequential	31 (115.8)	75.9 (25.3)	29.6 (12.9)	56.7 (25.6)	
Heritage Simultaneous	30 (11.3)	67.6 (26)	32.6 (16.3)	78.6 (20.9)	
	Mean (Standard Deviation)				
Participant Group	Only Tap Occlusion	Only Trill Occlusion	Contrast Tap Occlusion	Contrast Trill Occlusion	
L1 Spanish	0.58 (0.51)	1.89 (1.03)	0.70 (0.46)	1.44 (1.04)	
L2 Spanish	0.49 (0.58)	0.87 (0.78)	0.51 (0.55)	0.66 (0.92)	
Heritage Sequential	0.87 (0.48)	1.49 (1.12)	0.82 (0.52)	1.10 (0.73)	
Heritage Simultaneous	0.91 (0.34)	1.88 (0.85)	0.93 (0.45)	2.02 (0.85)	

Table 1. Descriptive statistics according to rhotic duration in milliseconds and number of apical occlusions.

3. Results

Two linear mixed effects models using a Satterthwaite approximation for degrees of freedom were run using R to determine the relationship between participant group and rhotic context (R Core Team 2013). The models each included rhotic duration or number of apical occlusions as the dependent variable, an interaction of participant group and rhotic context, type of task as a fixed effect, and a random intercept by participant. Both models included L1 Spanish speakers, the "only tap" rhotic context, and the picture naming task as baselines (Table 2). Language dominance was not included as a factor in these analyses given that only two of the twenty-four participants self-identified as Spanish-dominant, according to the Bilingual Language Profile. A visualization of the data comparing the English- and Spanish-dominant heritage speakers found both Spanish-dominant heritage speakers to produce fewer occlusions overall than the English-dominant speakers. As for rhotic duration, the simultaneous bilingual, but not the sequential bilingual, produced rhotics with a shorter duration.

The results of the linear mixed effects model with duration as the dependent variable showed a significant main effect for participant group, rhotic context, and type of task, as well as significant inter-speaker variation in each group. Figure 3a illustrates a comparison of rhotic sound duration organized by participant group and Figure 3b illustrates a comparison of number of apical occlusions organized by rhotic context.

Figure 3. Boxplot for (**a**) duration (milliseconds) of the rhotic sounds according to participant group (*y*-axis) and rhotic context (fill) and (**b**) number of apical occlusions according to rhotic context (*y*-axis) and participant group (fill).

Duration	Estimate	SE	t	p
L2 Spanish	-0.788	1.504	-0.524	0.600
Heritage Simultaneous	4.049	1.378	2.939	0.003
Heritage Sequential	0.59	1.400	0.421	0.674
Only Trill	-2.412	1.597	-1.511	0.131
Contrast Tap	3.236	1.897	1.706	0.088
Contrast Trill	-34.991	1.742	-20.086	< 0.001
Task Storytelling Task	-7.481	1.346	-5.559	< 0.001
L2 Spanish x Only Trill	6.713	2.566	2.617	0.009
Heritage Simultaneous x Only Trill	4.554	2.522	1.806	0.071
Heritage Sequential x Only Trill	-2.519	2.573	-0.979	0.328
L2 Spanish x Contrast Tap	-10.890	3.348	-3.253	0.001
Heritage Simultaneous x Contrast Tap	-11.238	2.996	-3.751	< 0.001
Heritage Sequential x Contrast Tap	7.287	3.009	2.422	0.016
L2 Spanish x Contrast Trill	24.943	2.987	8.350	< 0.001
Heritage Simultaneous x Contrast Trill	-3.033	2.778	-1.092	0.275
Heritage Sequential x Contrast Trill	0.673	2.801	0.240	0.810
Number of Occlusions	Estimate	SE	t	р
L2 Spanish	-0.152	0.083	-1.843	0.066
Heritage Simultaneous	0.238	0.071	3.357	0.001
Heritage Sequential	0.223	0.081	2.756	0.006
Only Trill	1.051	0.093	11.263	< 0.001
Contrast Tap	0.025	0.081	0.305	0.761
Contrast Trill	0.689	0.078	8.998	< 0.001
Task Storytelling Task	-0.188	0.049	-3.866	< 0.001
L2 Spanish x Only Trill	-0.816	0.166	-4.905	< 0.001
Heritage Simultaneous x Only Trill	-0.090	0.137	-0.652	0.514
Heritage Sequential x Only Trill	-0.505	0.139	-3.644	< 0.001
L2 Spanish x Contrast Tap	-0.037	0.127	-0.289	0.773
Heritage Simultaneous x Contrast Tap	-0.004	0.128	-0.029	0.977
Heritage Sequential x Contrast Tap	-0.089	0.130	-0.680	0.496
L2 Spanish x Contrast Trill	-0.548	0.130	-4.201	< 0.001
Heritage Simultaneous x Contrast Trill	0.415	0.127	3.276	0.001
Heritage Sequential x Contrast Trill	-0.465	0.137	-3.393	0.001

Table 2. Descriptive statistics according to rhotic duration in milliseconds and number of apical occlusions.

The results of the model with occlusion as the dependent variable showed a significant main effect for participant group, rhotic context, and type of task. Figure 4a illustrates a comparison of number of apical occlusions by participant group according to rhotic context and Figure 4b illustrates a comparison of apical occlusion by participant group according to phonemic tap.

Figure 4. Bar plot for number of apical occlusions of the rhotic sounds according to participant group and (**a**) rhotic context and (**b**) phonemic tap.

As for the interactions, the model analyzing rhotic duration found a significant interaction of L2 Spanish speakers and the "only trill", "contrast tap", and "contrast trill" contexts, simultaneous

bilingual heritage speakers and the "contrast tap" context, and sequential bilingual heritage speakers and the "contrast tap" context. The model analyzing number of apical occlusions showed significant interactions between L2 Spanish speakers and the "only trill" and "contrast trill" contexts, as well as between the simultaneous bilingual heritage speakers and the "contrast trill" context. Additionally, sequential bilingual heritage speakers were found to interact significantly with the "only trill" and "contrast trill" contexts.

Pairwise comparisons were run to compare all participant groups and rhotic contexts using the estimated marginal means (EMMs) function in R (Lenth 2018). The differences between all participant groups, according to rhotic duration, were not found to be significant except between L1 Spanish speakers and simultaneous bilinguals and L2 Spanish speakers and simultaneous bilinguals (p < 0.02). As for rhotic context, all contexts were found to be significantly different from each other, except for two contrasts: only tap and contrast tap, and only trill and contrast trill (p > 0.98). The pairwise comparisons for the model analyzing number of apical occlusions showed significant differences between all participant groups except for the L1 Spanish speakers and the sequential bilinguals. All rhotic contexts were found to be significantly different from each other except for the only tap and contrast tap contexts and the only trill and contrast trill (p > 0.8). The statistically significant EMMs can be found in Table 3.

Duration	Estimate	SE	t	p
L1 Spanish—Heritage Simultaneous	-4.049	1.378	-2.938	0.018
L2 Spanish—Heritage Simultaneous	-4.837	1.609	-3.007	0.014
Only Tap—Only Trill	-28.820	1.552	-18.576	< 0.001
Only Tap—Contrast Trill	-29.356	1.370	-21.428	< 0.001
Only Trill—Contrast Tap	29.335	1.637	17.916	< 0.001
Contrast Tap—Contrast Trill	29.870	1.527	19.556	< 0.001
Number of Occlusions	Estimate	SE	t	р
L1 Spanish—L2 Spanish	0.502	0.054	9.197	< 0.001
L1 Spanish—Heritage Simultaneous	-0.318	0.050	-6.358	< 0.001
L2 Spanish—Heritage Sequential	-0.821	0.059	-14.018	< 0.001
L2 Spanish—Heritage Simultaneous	-0.461	0.059	-7.780	< 0.001
Heritage Simultaneous—Heritage Sequential	0.360	0.056	6.471	< 0.001
Only Tap—Only Trill	-0.698	0.057	-12.342	< 0.001
Only Tap—Contrast Trill	-0.549	0.050	-11.047	< 0.001
Only Trill—Contrast Tap	0.706	0.060	11.807	< 0.001
Contrast Tap—Contrast Trill	0.557	0.056	10.006	< 0.001

Table 3. Statistically significant estimated marginal means (EMMs) for all participant groups and rhotic contexts.

4. Discussion

The current study examined the effects of age of onset of bilingualism and cross-linguistic influence on the production of the Spanish alveolar tap and alveolar trill by adult simultaneous bilingual heritage speakers, sequential bilingual heritage speakers, and L2 Spanish learners. Sequential bilinguals experience a period of monolingualism in the heritage language (Spanish) and acquire the majority language (English) once they start attending school. Simultaneous bilinguals, on the other hand, grow up in a bilingual environment in which they simultaneously acquire English and Spanish at home. This difference in age of onset of bilingualism may influence the acquisition of the Spanish rhotic system; it is possible that simultaneous bilinguals may not have received enough Spanish input in childhood to fully acquire the L1 sound categories of the alveolar tap and trill, unlike sequential bilinguals who experienced years of monolingual Spanish input. Indeed, bilingual Spanish-speaking children demonstrate great variability when reaching target-like production of these two phonemes, possibly due to the difference in their childhood Spanish-language input (Carballo and Mendoza 2000; Jimenez 1987; Kehoe 2018). It was predicted that sequential bilingual heritage speakers would pattern more similarly to L1 speakers of Spanish in their production of the alveolar tap and trill than the simultaneous bilingual heritage speakers (Flege and Bohn 2020; Henriksen 2015; Kim and Puigdelliura 2019; Kissling 2018).

When producing Spanish words containing a rhotic sound, the sequential bilingual heritage speakers, but not the simultaneous bilingual heritage speakers, produced the alveolar tap and trill with a similar duration and number of apical occlusions to the productions of the L1 speakers of Spanish. This result may be due to an incomplete acquisition of the Spanish rhotic system by the simultaneous bilingual heritage speakers. According to previous research, Spanish-speaking children acquire the alveolar tap by five years of age and the alveolar trill by age 6;6 (Carballo and Mendoza 2000; Jimenez 1987; Kehoe 2018). The simultaneous bilingual speakers recorded in this experiment reported being exposed to both English and Spanish by age 1;8, while the sequential heritage speakers reported their average exposure to English starting at age six. Due to their early exposure to English, the simultaneous bilinguals may not have received enough Spanish input to fully define L1 categories for the Spanish rhotic system. This result parallels previous research on heritage language production and language dominance (Goldstein et al. 2005; Kim and Puigdelliura 2019; Kissling 2018).

Despite performing differently than the L1 Spanish speakers, the simultaneous bilingual heritage speakers maintained a distinct articulatory difference between the alveolar tap and trill, in terms of rhotic duration and number of apical occlusions. As seen in Figure 3a,b, the simultaneous bilingual heritage speakers successfully differentiated the alveolar tap and trill in both "only" and "contrast" contexts. In other words, the simultaneous bilingual heritage speakers maintained two separate phonetic categories for the alveolar tap and trill, suggesting that they had been exposed to enough Spanish input in childhood to distinguish the phonetic differences between these two sounds. However, the simultaneous and sequential bilingual heritage speakers differed in the number of apical occlusions produced for the alveolar trill in the "contrast trill" context and the rhotic duration of alveolar taps in the "contrast tap" context. It is possible that heritage speakers gained the ability to perceive but not to produce the alveolar tap and trill in childhood. Thus, the simultaneous bilinguals may be able to produce two distinct sounds but be unaware of the "native" duration of the alveolar trill. This result parallels that of previous heritage language research, which has found heritage speakers to resemble but not replicate the productions of L1 speakers of the heritage language (Chang et al. 2008, 2011; Kim 2015, 2019; Ronquest 2013).

The second research question asked whether the heritage speakers would transfer the English alveolar approximant onto the Spanish alveolar tap or trill. Although the focus of this study is the production of Spanish rhotics, English data was previously collected from the simultaneous bilinguals and sequential bilinguals who participated in this study and compared to productions of L1 English speakers. The participants completed a storytelling task and a picture naming task in English. The alveolar approximants produced in intervocalic position by these participants were examined according to F3 and F3-F2 values. Results of two linear mixed models showed that the simultaneous bilinguals (who had received English input in early childhood) produced more target-like English rhotics than the sequential bilinguals (who had minimal to no English input in early childhood). This result supports the predictions of the SLM; the simultaneous bilinguals were able to separate their language systems while the sequential bilinguals demonstrated a non-target-like production of the English alveolar approximant, possibly due to influence from the Spanish rhotic system. Despite differing in terms of their articulations, both heritage participant groups produced F3 values that overlapped with that of the L1 English speakers' rhotic productions, demonstrating that they approached target-like articulations of the canonical alveolar approximant (Figure 5).

Figure 5. Boxplot for F3 value of the alveolar approximant according to participant group.

According to the SLM, the phonetic elements of bilinguals' two languages—in this case, Spanish and English—exist in one common space, meaning that they can potentially influence each other (Flege 1995, 2007). The SLM also posits that bilinguals reorganize their phonetic categories during L2 acquisition. Given that Spanish represented the heritage speakers' L1 and the lack of transfer found in previous heritage language studies, it was expected that neither heritage speaker group would produce the English rhotic sound when speaking Spanish (Henriksen 2015; Kissling 2018; O'Rourke and Potowski 2016).

Of all the rhotic tokens produced by both heritage speaker groups, no examples of the alveolar approximant were recorded. This result supports findings following the SLM. Flege (1991), for example, tested L1 Spanish L2 English learners and Spanish-English (heritage) bilinguals in their production of Spanish /d/ and English /t/. While both groups produced the Spanish /d/ similarly, only the heritage speakers produced the English /t /in a native-like way. This result suggested that the heritage speakers successfully categorized the Spanish /d/ and English /t /as two different phonetic categories. Similarly, the heritage speakers in the current study separated their two language systems and produced only the alveolar tap and trill in Spanish.

Although the heritage speakers did not produce any examples of the English alveolar approximant, they did produce cases of assibilate rhotic (Figure 4b). These allophones to the Spanish tap and trill form part of dialectal variants found in Central America, the Andean region, Paraguay, and Argentina (Bradley and Willis 2012; Colantoni 2006; Diaz-Campos 2008; Hualde 2005; Lastra and Butragueño 2006). This result suggests that both sequential and simultaneous bilingual heritage speakers are aware of dialectal rhotic allophones and are able to produce them with the same frequency as L1 speakers of Spanish. It is possible that limited but continued exposure to the heritage language throughout childhood may prove to be sufficient to allow heritage speakers to both perceive and produce these dialectal variants.

The third research question asked whether the L2 learners would pattern differently to the heritage participants in their production of the alveolar tap and trill. While heritage speakers are exposed to varying amounts of Spanish input throughout childhood, L2 learners grow up in a monolingual English environment and develop a stable L1 sound system by the time they start acquiring their second language. The assimilative power of their L1 on the production of their L2 may be greater than that of heritage speakers. Thus, these learners were expected to replace the alveolar tap with the English alveolar approximant [I] and overgeneralize the production of the alveolar tap in contexts where the alveolar trill is required.

Although the L2 learners did not differ significantly from L1 Spanish speakers in terms of rhotic duration, they did differ significantly in terms of the number of apical occlusions produced. Furthermore, they were found to replace Spanish rhotics with the English alveolar approximant, as seen in Figure 4b. This result supports the research in Face (2006), which found intermediate L2 Spanish learners to replace Spanish rhotics with the alveolar approximant. As for their alveolar trill, the L2

learners produced significantly longer durations for the "only trill", "contrast tap", and "contrast trill" contexts and more apical occlusions for the "only trill" and "contrast trill" contexts. This difference may be due to learners having to emphasize the rhotic in order to differentiate between minimal pairs. That is, the learners may have produced a longer rhotic with more apical occlusions for the "contrast trill" context because producing a short duration or fewer occlusions would have affected the comprehension of that word, as in *caro* 'expensive' and *carro* 'car'. This result is also present in Face (2018). In his study, L1 English L2 Spanish learners who had lived in Spain for 10+ years were found to produce the most target-like rhotics when there was a phonemic contrast between the tap and trill. It is also important to note that the type of task (storytelling task, picture naming task) affected the duration and number of apical occlusions of the rhotics produced by the participants. As seen in Figure 6a,b, L2 learners produced no examples of rhotics with three occlusions when completing the picture naming task but did produce these multiple occlusions when completing the storytelling task. This may reflect an ease in producing more target-like articulations in controlled speech as opposed to semi-spontaneous speech. On the other hand, the L2 learners patterned more similarly to the L1 speakers than either heritage group in terms of duration of the rhotic sound. Further analysis is required in order to make any conclusions regarding the effect of type of task on Spanish rhotic productions.

Figure 6. Boxplot for (**a**) rhotic duration according to participant group by task and (**b**) number of apical occlusions according to participant group by task.

It must be noted that the L2 learners tested in this experiment demonstrated a lower proficiency than the participants in Face (2006, 2018). Of the six L2 learners participating in this study, only one had a Spanish proficiency above high-beginner, according to the DELE Spanish Proficiency Test. The heritage speakers, on the other hand, demonstrated a proficiency level of high-intermediate or higher. Thus, although the L2 learners here patterned similarly in their production of the alveolar approximant and the overgeneralization of the alveolar tap as L2 learners in other research studies, the L2 learners, sequential bilingual heritage speakers, and simultaneous bilingual heritage speakers tested in this study may not be comparable in terms of their early language input (as expected) but also in their actual exposure and use of the language¹ (Face 2006, 2018; Olsen 2012, 2016).

To summarize, three predictions were made to answer the following three research questions: do simultaneous and sequential bilingual heritage speakers of Spanish pattern differently from each other and from L1 Spanish speakers in their production of Spanish rhotics, do these heritage speakers transfer the English alveolar approximant onto the Spanish rhotic system, and do L2 learners and heritage speakers pattern differently in their production of Spanish rhotics? The first prediction expected the sequential bilingual heritage speakers to produce both alveolar taps and trills more like

¹ Face (2006, 2018) found advanced-proficiency L2 Spanish learners to display a low rate of accuracy when producing alveolar trills and did not approximate native-speaker performance. Although the simultaneous bilingual data in this study differed significantly from that of L1 speakers, we believe that their productions would be more target-like than those of advanced-proficiency L2 Spanish speakers.

the L1 speakers than the simultaneous bilingual heritage speakers. The second prediction expected neither heritage speaker group to transfer the English alveolar approximant onto the Spanish alveolar tap and trill. The third prediction expected the L2 learners to be less target-like in their productions than the heritage speakers. The results confirmed the first prediction, in that the sequential bilinguals produced Spanish rhotics like L1 speakers for duration and number of apical occlusions. The results confirmed the second prediction, suggesting that limited Spanish input in childhood may suffice in allowing heritage speakers to limit transfer between their two languages. Finally, the results confirmed the third prediction, in that the L2 learners produced the alveolar approximant in lieu of the alveolar tap and overgeneralized the tap when the trill was required.

The current study provides several opportunities for expansion, replication, and alteration. While the current study only analyzed the Spanish rhotics of sequential and simultaneous bilingual heritage speakers, it is possible that their Spanish (L1)—especially that of the sequential bilinguals—may influence their English (L2) rhotic productions. Although no previous study has reviewed the production of the English alveolar approximant by heritage speakers of Spanish, Amengual (2018) examined the production of English-Spanish /l/ by heritage speakers of Spanish and found those heritage speakers who had more exposure to Spanish (generation 1.5) to produce lighter /l/'s in English than heritage speakers with more English exposure (generation 3). Thus, a more detailed analysis of English productions of these heritage speakers than the one described above should be considered and may provide additional information regarding phonetic transfer from the L1 onto the L2. Additionally, this study only reviewed the Spanish rhotic production of heritage speakers of Mexican Spanish. Research on Caribbean Spanish has reported a neutralization of the alveolar tap and the lateral /l/, but this neutralization has not been examined in heritage speakers of Spanish (Hualde 2005; O'Rourke and Potowski 2016). Future research could potentially test heritage speakers of Caribbean Spanish to explore the acquisition of dialectal rhotic allophones.

5. Conclusions

The current study aimed to determine whether childhood Spanish input and cross-linguistic influence affected the alveolar tap and trill production of adult sequential bilingual heritage speakers, simultaneous bilingual heritage speakers, and L2 Spanish learners. When producing Spanish words in a storytelling task and a picture naming task, the sequential bilinguals produced a similar alveolar tap and trill to that of L1 Spanish speakers for duration but not for number of apical occlusions. The simultaneous bilinguals produced significantly different rhotic productions to the L1 speakers for both duration and number of apical occlusions. The L2 learners produced less target-like rhotics than the heritage speakers and transferred the English alveolar approximant onto their Spanish.

The results of this study suggest that limited or lack of childhood input in the heritage or second language may negatively affect bilingual speakers' production of sounds acquired late in childhood. However, even limited childhood input may be enough to avoid transfer from one language onto another. The production of rhotic sounds by bilingual speakers requires further research to test whether different Spanish varieties produce similar results or whether heritage speakers also limit their cross-linguistic influence when producing the English rhotic sound.

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Appendix A

Target Words			
tambores	cura		
loro	oro		
toro	zorro		
mora	burro		
cero	correa		
pera	carro		
coral	barra		
Paris	barril		
nariz	arroz		

Table A1. Target words used in the picture naming task.

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