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LIMITATIONS OF THE INFLUENCE OF ENGLISH PHONETICS AND PHONOLOGY ON L2 SPANISH RHOTICS

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ABSTRACT. This study investigates L2 Spanish rhotic production in intermediate learners of Spanish, specifically addressing the duration of the influence of L1 English[1] rhotic articulations and a phonological environment involving English taps on the acquisition of Spanish taps and trills that Olsen (2012) found. Results from multiple linear regressions involving thirty-five students in Spanish foreign language classes show that the effect of English rhotic articulations evident in beginners has disappeared after four semesters of Spanish study. However, results from paired samples *t*-tests show that these more advanced learners produced accurate[2] taps significantly more in words containing phonological environments that produce taps in English. This effect is taken as evidence that L1 phonetic influences have a shorter duration on L2 production than do L1 phonological influences. These results provide insights into L2 rhotic acquisition which Spanish educators and students can use to formulate reasonable pronunciation expectations.

Keywords: L2 pronunciation; L2 Spanish rhotics; L1 influence; Spanish second language acquisition; Spanish phonological acquisition

RESUMEN. Este estudio investiga la producción de las róticas en español en estudiantes de español como L2 de nivel intermedio. Específicamente aborda la duración de la influencia de la articulación de róticas en inglés y entornos fonéticos que involucran vibrantes en inglés, que es la L1 de los estudiantes, en la adquisición de vibrantes en español (ver Olsen 2012). Los resultados de regresiones lineales múltiples con datos de treinta y cinco estudiantes muestran que el efecto de la articulación de róticas en inglés, evidente en principiantes, ha desaparecido tras cuatro semestres de estudio de español. Sin embargo, los resultados de pruebas t pareadas indican que estos estudiantes más avanzados producen más vibrantes simples con precisión en palabras que contienen entornos fonéticos que también las requieren en inglés. Se interpreta este efecto como evidencia de que la influencia fonética en la producción de una L2 tiene menos duración que la influencia fonológica. Estos resultados proporcionan información sobre la adquisición de róticas en español, que docentes y estudiantes pueden usar para formular expectativas razonables de pronunciación.

Palabras clave: pronunciación de L2; róticas del español como L2; influencia de la L1; adquisición del español como segunda lengua; adquisición de la fonología del español

[1] All instances of the word 'English' refer to General American English.
[2] Accuracy herein does not refer to the 'correctness' of an articulation since native rhotic articulations are variable and many would be considered inaccurate under such a framework. Accuracy, as conceptualized in this study, refers to the proximity to the ideal target articulation described in the literature and accepted for the majority of native Spanish speakers and learners alike. Although I acknowledge the variability among native Spanish rhotic articulations, the focus of this study is on the L2 acquisition of the ideal—the first piece of the English rhotic influence on L2 Spanish rhotics puzzle.

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1. Introduction

Studies on second language (L2) phonological acquisition have mainly focused on hypotheses of cross-linguistic markedness, language typology, and perceptual similarity (see Eckman 2008). Colantoni and Steele (2008) discussed the need to incorporate phonetic constraints into hypotheses regarding L2 phonological acquisition. Their study showed that the current phonological and phonetic models did not adequately predict the variation and acquisition sequences they found in rhotic pronunciation by speakers of English as a first language (L1) learning L2 French and Spanish. They showed that phonetic factors evident in L2 speech such as word-position and manner of articulation are not included in the theories they tested and proposed that phonetic factors should be considered in L2 phonological acquisition. Carrying out studies that include L2 phonetic phenomena that may influence the acquisition of L2 phonological systems is therefore important. At least one other study has considered phonetic phenomena in L2 rhotic acquisition.

Olsen (2012) examined specific L1 articulatory routines that are not necessarily predisposed by aerodynamics (i.e., tongue shape in English rhotic articulation) as well as the L1 phonological environment that produces allophonic taps from alveolar stops (i.e., /t/ and /d/). Olsen showed that L1 rhotic articulations affected the accuracy of L2 rhotic pronunciation only at the onset of the segmental acquisition of rhotics. The results also suggested that the L1 phonological environment predicting allophonic variation was likewise important in L2 rhotic accuracy. The current study adds to this body of research by investigating the robustness of the L1 influences found in Olsen (2012).

The number of studies investigating the L2 acquisition of Spanish rhotics has increased in recent years. Face (2006) investigated intervocalic rhotics among intermediate and advanced L2 Spanish learners whose L1 was English and noted a general increase in accuracy as proficiency increased. Rose (2010a) tested the predictions of the Perceptual Assimilation Model (Best 1995) in L2 learners' perceptual discrimination of rhotics and found that the ability to perceptually discriminate Spanish alveolar taps, trills, stops, and affricates generally increased with proficiency level. Rose (2010b) described the range of phones that L1 English speakers utilize for L2 Spanish rhotics in intervocalic position. The results of Rose's study suggest that L2 learners employ [ɹ] in all Spanish rhotic contexts at first, moving to more [ɾ]-dominant articulations for all rhotics and finally differentiating [ɾ] and [r] at the more advanced levels. Waltmunson (2005) investigated the relative difficulty of the acquisition of rhotics with respect to /t/ and /d/. Waltmunson's study places the acquisition of L2 Spanish rhotics to be more difficult relative to the acquisition of other L2 Spanish phones in intervocalic position, furthering our knowledge of where rhotics are situated in the larger picture of L2 Spanish phonology acquisition. Rose (2012) examined how English speaking L2 Spanish learners discriminate /ɾ/-/r/, /ɾ/-/t/, and /ɾ/-/d/ and found that the latter contrast was most difficult to discriminate. Daidone and Darcy (2014) also investigated /ɾ/-/r/, /ɾ/-/t/ and /ɾ/-/d/ contrasts and suggested that difficulty in discrimination among these contrasts stems from how learners encode words. Rose explained that the /ɾ/-/d/ contrast is the most difficult to discriminate because L1 English speakers often categorize both to /d/.

Other studies have investigated how instruction and training affect the L2 acquisition of Spanish rhotics. Hurtado and Estrada (2010) investigated linguistic (phonological environment and tap/trill pronunciation) and sociolinguistic factors that contributed to the pronunciation of Spanish rhotics by L1 English speakers and found that linguistic factors, input received through study abroad, and explicit instruction improved pronunciation. Herd, Jongman, and Sereno (2013) compared three different training approaches to improve perception and production of Spanish rhotics. All training groups (perception, production, and combination) in this study improved significantly in perception and production over a control group. Furthermore, the combination of perception and production training helped learners improve in their production better than the other training types, whereas perception and production training types helped learners improve perception. In a cross-modal priming study using the same participants, Herd, Jongman, and Sereno (2015) showed that training also led learners to process matched prime-target pairs faster than mismatched pairs, approaching native phonological processing. Lord (2005) also included trills in a study on how a Spanish phonetics course improved Spanish pronunciation. She found that explicit phonetics instruction, self-analysis, and production practice improved trill accuracy over the span of a semester.

These studies have contributed to our understanding of the potential factors that affect the production of Spanish rhotics by L1 English speakers, which necessitates the incorporation of L1 and L2 phonetics. These studies have also provided a description of the Spanish rhotic developmental process, how instruction affects the developmental process, and how L1 phonetics and phonology influence L2 rhotic accuracy for L1 English speakers. One question regarding the L2 acquisition of Spanish rhotics that still remains unanswered, at least empirically, is whether the L1 influence found in beginners is evident in more proficient L2 learners. That is to say, do the phonological environments in which English alveolar stops are realized as taps and L1 English rhotic articulatory routines influence the production of L2 Spanish rhotics in learners after four semesters of language study? The current study aims to investigate the interlanguage state of Spanish rhotics among more proficient L2 learners with respect to these phonological and phonetic influences. Also, although Olsen (2012) found that L1 English rhotic articulation affected the accurate production of Spanish trills, the number of trills elicited was very small. The current study therefore also aims to improve methodological considerations by increasing the number of trill elicitations.

2. Background

2.1 English Rhotics

In order to contextualize the investigation of L1 English phonetic and phonological influences on L2 Spanish rhotic pronunciation, a brief description of the English and Spanish rhotic systems is presented here. English has one phonemic rhotic /ɹ/ which can be produced utilizing two maximally distinctive articulations--"retroflex" and "bunched" (Delattre & Freeman 1968). These descriptions depict the shape of the tongue when producing [ɹ]. Speakers who employ a retroflex [ɹ] lift the apex of their tongue up and curl it back towards the dorsum. Speakers who employ a bunched [ɹ] contract their tongue back into a tight bunch near the rear of their buccal cavity. Although these descriptions are presented in categorical terms, the reality is that variation between fully retroflex and fully bunched exists in actual articulations (Espy-Wilson, Boyce, Jackson, Narayanan, & Alwan 2000). Regardless of slight variations, Zhou, Espy-Wilson, Tiede, and Boyce (2007) and Zhou, Espy-Wilson, Boyce, Tiede, Holland, and Choe (2008) showed that there is a greater difference between formants four and five (F4 and F5 respectively) in retroflex (around 1400 Hz) than in bunched (around 700 Hz) productions. These differences in distance between F4 and F5 are acoustic measures that correlate with the length and ratio between anterior and posterior (relative to the tongue) resonating cavities. The longer the posterior cavity is (which correlates with articulations that raise the tongue apex), the greater the distance between F4 and F5. Further work associating acoustic information with articulatory correlates has corroborated these findings. Espy-Wilson and her colleagues have developed a speech inversion system mapping from acoustics to articulations that has been trained using X-ray microbeam data including many utterances of /ɹ/ from native English speakers. When submitting acoustic information found in Zhou et al., the system gave tract variables (i.e., articulations) corresponding to retroflex and bunched articulations (Espy-Wilson, personal communication, June 6, 2016). Because perception relies more heavily on the lower formants, these acoustic differences between retroflex and bunched articulations go unnoticed by native English speakers and can be described as unperceived phonetic details.

English also has an allophonic segment comparable to one of the Spanish rhotics that can be described as an alveolar tap. According to Ladefoged (2006), English taps are allophones of alveolar stops which are realized in intervocalic position and before an unstressed vowel as in *city* [ˈsɪɾi] or *Adam* [ˈaɾəm]. Kahn (1980) also asserts that the vital part of tap realization is that the following vowel be unstressed because taps can be realized following stressed vowels as in the examples previously mentioned or unstressed vowels as in *animosity* [ænɪˈmasɪɾi]. Although researchers generally agree on this simple description of the English tap, the exact phonological environment that produces taps has been the topic of debate (Edington & Elzinga 2008). In addition to stress, other features that have been purported to affect the realization of the allophonic tap include voicing, preceding vowel duration, syllabification, and (morphological) paradigm uniformity (e.g., Braver 2014; Davis 2003; de Jong 1998; Eddington 2006; Eddington & Elzinga 2008; Fox & Terbeek 1977; Kahn 1980; Riehl 2003; Steriade 2000). Kiparsky (1979), for example, argues that the trigger for tapping is not surface syllable structure; rather, tapping occurs because of the ambisyllabic nature of consonants in foot-medial position. Eddington and Elzinga (2008) found that stress was the main factor in tap realization when looking at stress, syllabification, and following vowel as variables. In their distributional analysis of the CMU Pronouncing Dictionary (n.d.), they found that stressed preceding vowels and unstressed following vowels was the phonological environment with the highest frequency of tap realization. Although there continues to be some debate on the exact phonological environment that produces allophonic taps in English, the evidence to date indicates the primacy of stress in relation to the realized phone stated succinctly in Ladefoged's (2006) definition.

2.2 Spanish Rhotics

Spanish has two phonemic rhotics –a tap /ɾ/ and a trill /r/. The full phonemic status of each rhotic has been the topic of some debate (see Hualde 2005b). The one phonemic rhotic analysis argues that [r] is an allophone of /ɾ/ because these two phones only contrast in word-internal intervocalic position. Harris (2001) explains this distribution by positing underlying /ɾɾ/ when [r] occurs intervocalically. However, assuming that a perceptual difference between phones in speakers' minds is necessary to maintain differences in meaning between minimal pairs, I maintain the two-phoneme analysis evidenced in minimal pairs such as *pero* [ˈpe.ɾo] 'but'-*perro* [ˈpe.ro] 'dog'.

Speakers produce taps by raising the apex of the tongue towards the alveolar ridge and making a very brief closure. Trills are produced by raising the apex of the tongue toward the alveolar ridge and making a short sequence of brief closures created by a steady pulmonic egressive force (Hualde 2005a; Navarro Tomás 1918). Solé (2002) studied the differences in aerodynamic forces required to produce trills and described the force needed for trill production. As the tongue apex comes into contact with the alveolar ridge, oropharyngeal pressure builds until it overcomes the obstruction caused by the tongue. When pressure is released, the tongue apex recoils into the same position and the cycle continues through the duration of pronunciation. In her study on aerodynamic factors in trill production, Solé also showed that trills usually entailed a succession of four, and sometimes five or six quick closures. However, she also cites Barry (1997) and Blecua (1999) who suggest that subjects often hyperarticulate in laboratory conditions, and that less closures are more common. Indeed, others have described trills to normally consist of two to three occlusions (Rose 2010a).

Producing apical trills is physiologically difficult in comparison to other consonants. The 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. Perhaps because of these fine motor skills needed for trill articulation, trills are acquired late by L1 Spanish speakers (González 1989; Jiménez 1987; Vihman 1996). If L1 Spanish speakers acquire trills late in phonological development because of the physiological difficulty of producing trills, L2 learners may also experience difficulty when acquiring trills for the same reason.

Aside from intrapersonal variation, rhotic realization is also known to vary across dialects including fricative, lateralized, approximant, and semi-vocalic variants (Bradley 2004; Simonet, Rohena-Madrazo, & Paz 2008; Navarro Tomás 1918; Willis 2006; Willis & Bradley 2008). Although L2 learners might encounter a variety of rhotic realizations, including non-native productions, the variants they are taught in classroom learning in the United States can be described simply as alveolar taps and alveolar trills (Face 2006).

2.3 English-Spanish Interlanguage Rhotics

Although acoustic differences exist between different articulations of the English rhotic, these acoustic differences probably do not affect learners' perception and production of Spanish rhotics (Zhou et al. 2008). The physical differences in tongue position, however, may affect how accurate L2 learners are when producing Spanish rhotics. The apex of the tongue changes in relationship to the alveolar ridge depending on the articulation. English rhotic articulations that raise the apex in the buccal cavity are more like Spanish rhotic articulations than those that pull the apex back. Because movement of the apex involves neuromotor routines, L2 Spanish learners who employ articulations with a raised apex are predicted to be more accurate in Spanish rhotic production than those learners who do not.

The influence of English rhotic articulations on Spanish rhotic production may only be partly due to the fact that the English and Spanish phones are all considered liquids. Orthography also connects English rhotic neuromotor routines to Spanish rhotics. Because taps and trills are represented orthographically as <r> (trills are represented as <rr> intervocalically), inexperienced classroom learners' immediate response is to refer to the English rhotic /ɹ/ which shares the same grapheme (see Koda 1989; Munro & Derwing 1994; Zampini 1994 for the effects of orthography on the acquisition of second language sounds). This orthographic influence leads to the activation of the alveolar approximant /ɹ/ instead of the allophonic tap already present in the learners' representations or the trill which may not yet be added (Vokic 2011).

Aside from the phonetic influences of English rhotics, L2 learners must also acquire a phonological representation of Spanish rhotics. Assuming the L1 is the point of origin for L2 acquisition in adults, as do the current models explaining L2 phonology acquisition (see Best 1995; Flege1995; Iverson and Kuhl 1996), L2 Spanish learners must reanalyze the existing allophonic tap so that it gains phonemic status. In a study on the perception of the shared Spanish and English phones [d], [ð], and [ɾ], Boomershine, Hall, Hume, and Johnson (2008) found that their participants perceived the contrastive phones to be more distinct than the allophones of their native language. They also found that English speakers were least able to distinguish phone pairs involving [ɾ]. As part of the developmental process then, English speaking L2 Spanish learners need to perceptually distinguish /d/ and /t/ from [ɾ] so that it may gain full phonemic status in their Spanish inventory.

L2 learners must also add a trill to their phonological inventory. Applying Flege's Speech Learning Model (SLM), trills should be more easily acquired for L1 English speakers because they can create a new category instead of reassigning an existing sound to a new category. Nevertheless, learners may not be able to produce trills earlier than taps because of the articulatory difficulty involved (Face 2006). Another implication of the SLM is that taps will more than likely follow L1 phonological rules until they are phonemicized because they exist in the L1 inventory at an allophonic level. Before full tap phonemicization is complete in L2 Spanish learners, they are predicted to be more accurate with taps that occur in the same phonological environments that generate taps in English than other environments. Only when taps are phonemicized, will they transcend L1 distributional influences.

At a certain point in the interlanguage development of Spanish rhotics, L1 English speakers will have two Spanish rhotic categories which both include English rhotic realizations until the L1 influences are overcome. At the end stage of the interlanguage process, successful L2 learners will have two separate Spanish rhotic phonemes, a tap and a trill, as do native speakers (Hualde 2005b). The beginnings of this pattern are evident in Olsen (2012). Participants in Olsen's study (early beginners) had not overcome the L1 influence of the phonological environment that produces taps, nor had they acquired trills. Rose (2010b) investigated the range of rhotic variants produced by L2 learners of Spanish and showed that rhotic articulation developed in 5 stages. Her proposed stages are approximant-dominant, continuant-dominant with tap production, tap-dominant, association of frication with the phonological trill environment, and native-like differentiation. Although understanding Spanish rhotic developmental stages for L1 English speakers is important, a full description of the L2 Spanish rhotic developmental process should include the limits of L1 influences.

The purpose of the current study is to test whether the L1 influences found to affect L2 Spanish rhotic production also occur with more proficient learners, and is therefore a partial replication of Olsen's (2012) study. Evidence that more proficient learners have overcome the L1 influences mentioned above would show that these learners have already fully phonemicized the tap and fully acquired the trill. Otherwise, more exposure to Spanish, instructional training focusing on rhotics, or both may be needed to improve rhotic production. The specific research questions addressed are:

(1) Does the phonetic detail of American English rhotic articulation affect the facilitation of Spanish rhotic production among learners with intermediate levels of proficiency compared to beginners?
(2) Does the phonological environment that generates taps in English affect accuracy in Spanish rhotic production among learners with intermediate levels of proficiency compared to beginners?

3. Methods

3.1 Participants and Procedures

Thirty-five native English-speaking adults between the ages of nineteen and twenty-one from two fourth-semester Spanish language classes at a university in the Mid-Atlantic region of the United States were involved in this experiment. Thirty of the participants were female and 5 of the participants were male; a distribution reflecting usual class enrollment at the institution where the data were gathered. Students were either placed into the fourth semester class via a placement exam or had passed previous semesters of Spanish language classes to be enrolled in the class. The curriculum of the program in which the participants were students did not include explicit instruction on pronunciation; therefore, rhotic pronunciation was not a focus of instruction. Data were collected near the beginning of the semester. Participants rated their exposure to Spanish (including previous courses, travel abroad, reading, listening to music, watching television/movies, and other interactions with Spanish speakers) before taking the Spanish course in which they were currently enrolled on a Likert scale from one to seven where one equaled no exposure and seven equaled extensive exposure.

The exposure to Spanish ranking task revealed an expected distribution. The percentage of participants that indicated having a fair amount of exposure (Likert ranking of 4) was 40.0% (n=14). Nine participants indicated that they previously had a considerable amount of exposure to Spanish (Likert ranking of 5), while six participants indicated that they previously had some exposure to Spanish (Likert ranking of 3). Three participants indicated having little exposure (Likert ranking of 2) and three participants indicated having had a significant amount of exposure to Spanish (Likert ranking of 6) prior to enrollment. None of the participants indicated that they had extensive exposure to Spanish (Likert ranking of 7) prior to enrolling in the course. This distribution indicates that these participants did indeed have more exposure to Spanish than Olsen's (2012) participants, who's reported exposure to Spanish peaked at a Likert ranking of 2, and represent a group of learners with a higher proficiency level.

Participants were recorded reading two Spanish texts using Audio Recorder 3.2. The first text was adapted from a reading found in *Mosaicos 4th edition* (Castells, Guzmán, Lapuerta & García 2006) and contained 227 words. This text contained a total of thirty-two taps in the intervocalic position. Nineteen of these taps occurred in the same environment in which alveolar stops become taps in English, as in the word [ˈpe.ɾo] *pero* 'but'. Twelve of these taps occurred in other intervocalic environments, as in the word [di.fe.ˈɾen.t̪e] *diferente* 'different'. The text also contained four intervocalic trills.

The second text, written by the investigator, was a first-person narration of a couple of events in the life of the protagonist and contained a total of 339 words with forty-two trills in intervocalic position. Fourteen trills occurred in the same environment in which alveolar stops become taps in English, as in the word *perro* [ˈpe.ro] 'dog'. The other twenty-eight trills occurred in other intervocalic environments, as in the word *ocurrir* [o.ku.ˈriɾ] 'to occur'. Because this text was primarily used for the elicitation of intervocalic trills, taps and other trills that occurred in the text were not analyzed.

Additionally, separate analyses were carried out for word-medial intervocalic trills because of a possible graphemic influence on trills in intervocalic word-initial contexts (e.g., *la rama* [la.ˈra.ma] 'the branch'). The text included a total of thirty word-medial intervocalic trills and twelve word-initial intervocalic trills. Because word-initial trills are orthographically represented as a single <r>, the same way that taps are represented, the possibility that participants confuse trills and taps in word-initial position exists. In order to test whether this effect was evident among participants in this study, separate analyses were conducted excluding word-initial trills.

In order to test the influence of English rhotic articulation on the accuracy of Spanish rhotics, English rhotic articulation was determined for each participant. Participants recorded themselves pronouncing four English words containing [ɹ] –*arrow*, *car*, *proud*, and *heart* along with a prolonged [ɹ] pronunciation. Participants pronounced each word twice and held out the [ɹ] for a few seconds.

All recordings were analyzed using Praat (Boersma & Weenink 2009). Taps were considered accurate when a clear closure in the vocal tract was evident by a break in the formants (see Figure 1). Following Solé (2002), Barry (1997), and Blecua (1999), trills were considered accurate when at least two successive closures were evident as shown in Figure 2.

Figure 1. *Example of accurate tap articulation*

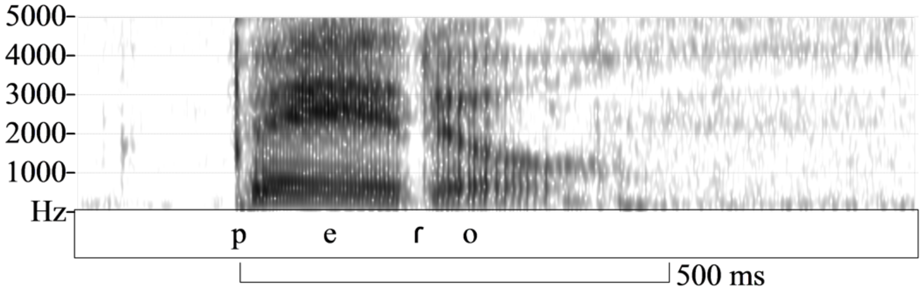
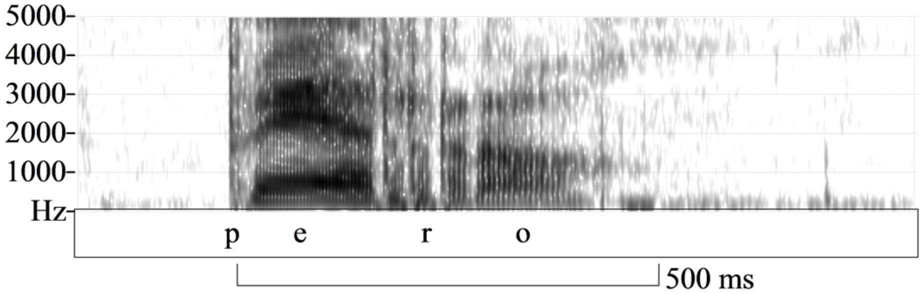


Figure 2. *Example of accurate trill articulation*

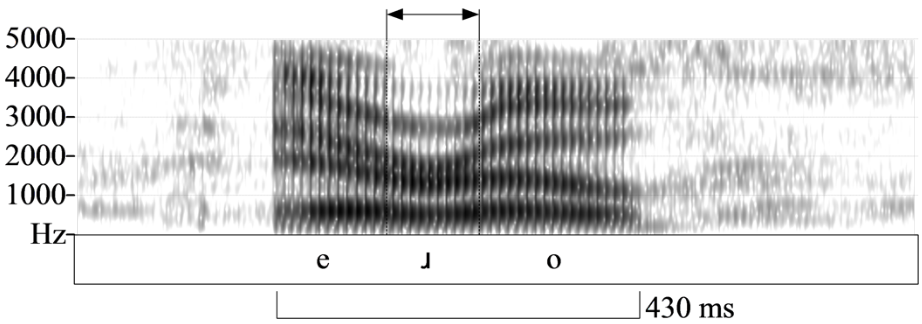


Participants of this study were expected to produce other realizations of Spanish rhotics besides canonical taps and trills as Rose (2010b) found. Due to the proficiency level of the participants, they should have passed at least the first level of Rose's proposed developmental trajectory. This expectation was confirmed by the non-canonical realizations that were produced. Participants produced taps, trills, or English rhotics (approximants) for all target realizations regardless of the elicited target. The non-canonical realizations were excluded from the analyses, however, because the focus of this study is to better understand the limitations of the L1 English rhotic influences on tap and trill accuracy.

Rhotic production accuracy rates were calculated for taps for each participant by dividing the total number of accurate taps by the total number of target taps in the text. Tap accuracy rates were also calculated for taps in phonological environments that produce taps in English (in intervocalic position and before an unstressed vowel) as well as those taps that were in other environments in order to test for the influence that the English phonological environment has on the accuracy of the production of Spanish taps. Trill accuracy rates were calculated in the same manner.

English rhotic articulation was measured for each participant by selecting the rhotic articulation in Praat, taking care not to include the surrounding sounds as shown in Figure 3. The difference between F4 and F5 was calculated from measurements taken every 6.25 milliseconds within each [ɹ] pronunciation and averaged for each participant. As mentioned in section 2, a greater distance between F4 and F5 translates into an articulation with a more highly raised tongue apex whereas a lower distance between F4 and F5 indicates an articulation with a lower tongue apex.

Figure 3. *Measurement of [ɹ] articulations*



4. Results

The average distance between F4 and F5 in the English rhotic productions varied among speakers, ranging from 616 Hz to 1559 Hz with a mean of 1035 Hz and a standard deviation of 220 Hz. Because English rhotic articulations in this study fell along a continuum, as was expected based on known variation in English rhotic articulation and results from Olsen (2012), they were analyzed as a continuous variable.

4.1 English rhotic influence on tap production

As for tap accuracy rates, twenty-eight English-speaking participants (82.9%) were able to produce at least one tap accurately. Of the participants who accurately produced at least one tap, accuracy rates ranged from 3.1% (1/32) to 100% (32/32) with a mean of 68.9%. A linear regression was performed (α=.05) to test whether English rhotic articulation was a predictor for tap accuracy. For tap accuracy, rhotic articulation (R^2=.020) was not a significant predictor (β=.141, p=.421).[3] A multiple linear regression was then performed to test whether English rhotic articulation was a predictor of tap accuracy, this time controlling for participants' amount of exposure to Spanish since Olsen (2012) showed that exposure was an important moderating factor. This test showed that neither English rhotic articulation (β=.160, p=.374) nor amount of exposure to Spanish (β=.100 p=.579), which combined accounted for 2.9% of the

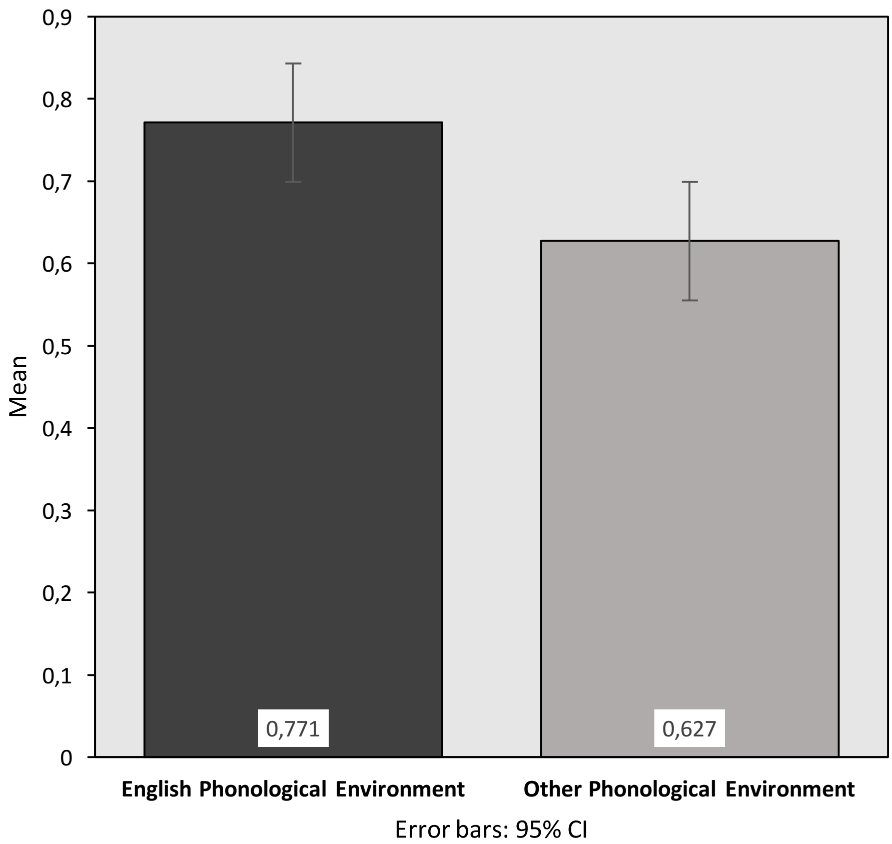
[3] All reported beta estimates are standardized.

variance (R^2=.029), were significant predictors of tap accuracy among these participants.

4.2 Influence of English phonological environment on tap production

Mean accuracy scores were calculated for each participant that produced at least one accurate tap (N=28) to test whether the phonological environment that generates taps in English affected Spanish tap accuracy. A paired-samples *t*-test compared the means of the accuracy scores of taps found in phonological environments that generate taps in English (M=77.1, SD=25.6) and taps found in other environments (M=62.7, SD=32.0). A significant difference was found between these means; $t(27)=4.473$, $p< .001$. Figure 4 shows the means of the accurate taps in the English phonological environment compared to the accurate taps in other environments.

Figure 4. *Means of accuracy rates of taps in different environments*



4.3 English rhotic influence on trill production

As for trill accuracy rates, fourteen English-speaking participants out of the thirty-five (40.0%) were able to produce at least one accurate trill. Of the participants who accurately produced at least one trill, accuracy rates ranged from 4.8% (2/42) to 69% (29/42) with a mean of 27.0% accurate trill production.

A linear regression was performed (α=.05) to test whether English rhotic articulation was a predictor for trill accuracy. For trill accuracy, rhotic articulation alone (R^2=.008) was not a significant predictor (β=.089, p=.610). A multiple linear regression was also performed to account for exposure to Spanish in trill accuracy rates. This test showed that English rhotic articulation (β=.159, p=.353) was still not a significant factor controlling for exposure to Spanish (β=.351, p=.045). Combined, these factors accounted for 12.6% of the variance (R^2=.126).

Separate linear regressions were performed excluding word-initial trills due to possible orthographic effects. When not controlling for amount of Spanish exposure, English rhotic articulation (R^2=.001) was not a significant predictor (β=.029, p=.869) of trill accuracy. When controlling for amount of exposure to Spanish, neither English rhotic articulation (β=.094, p=.586) nor amount of exposure to Spanish (β=.328 p=.063), which combined accounted for 10.4% of the variance (R^2=.104), were significant predictors of trill accuracy.

4.4 Influence of English phonological environment on trill production

Applying Flege's SLM (1995) to L2 Spanish rhotics, learners do not need to phonemicize trills because they do not exist in the English inventory. The English phonological environment that generates taps is therefore not predicted to affect trill production. However, trill accuracy rates were analyzed with respect to the English phonological environment that produces taps to rule out the possibility that differences in tap production in L2 learners is only due to stress patterns relative to general rhotic placement as Lewis (2004) found with native speakers. Results of this analysis will therefore aid in confirming an L1 phonological influence on tap production.

Mean accuracy scores were calculated for each participant that produced at least one accurate trill (N=14) to test whether the phonological environment that generates taps in English affected Spanish trill accuracy. A paired-samples *t*-test compared the means of the accuracy scores of trills found in phonological environments that generate taps in English (M=32.1, SD=24.1) and trills found in other environments (M=23.7, SD=20.2). A significant difference was not found between these means; *t*(13)=1.546, p=.146. A separate paired-samples *t*-test was also performed excluding word-initial trills. This test compared the means of the accuracy rates of word-medial trills found in phonological environment that generates taps in English (M=11.2, SD=19.9) and trills found in other environments (M=10.7, SD=18.7). A significant difference was not found between these means; *t*(34)=.221, p=.826.

5. Discussion

Because this study attempted to replicate Olsen (2012) with more proficient learners, the results will be discussed comparing the two studies. The overall accuracy rates of Spanish rhotics for Olsen's participants were quite low (for participants that produced any accurate rhotics, the mean for taps was 56.3% and for trills was 35.7%). This finding is not surprising because the native English-speaking participants were beginners. In this respect, the development of rhotics in L2 acquisition is similar to L1 Spanish speakers who acquire rhotics, especially trills, late in the developmental process (González 1989; Jiménez 1987; Vihman 1996). However, even at the beginning level, some participants did have a high tap accuracy rate and were able to produce trills. One explanation of this low accuracy rate in Spanish rhotic production is that the beginning learners had not received sufficient input and practice for their production to be reliable. Other researchers have also provided similar evidence of the effect of frequency in the input for general L2 acquisition (Ellis 2002; Ellis & Schmidt 1997; MacWhinney 2007). These learners are at a developmental stage where rhotics are just beginning to emerge which would begin to explain the wide range of accuracy rates across different participants.

The participants in the current study had a considerably higher tap accuracy rate than their beginner counterparts in Olsen (2012) with a mean of 68.9% for fourth semester learners compared to a mean of 56.3% for the beginners. A larger percentage of the fourth semester learners (82.9%) were able to produce taps compared to the beginners (64.6%) and generally at a higher level of accuracy overall, though some participants were still not able to accurately produce taps. These results were expected since these participants had much more experience with Spanish, but still indicate variable stages in the acquisition of taps at a higher proficiency level. The fact that a higher tap accuracy rate was produced by the more advanced learners supports Face's (2006) findings of improved Spanish rhotic production over time.

Trill accuracy rates of participants in the current study were also considerably higher. The percentage of participants that were able to produce trills (40.0%) was higher than the participants in Olsen (2012) (14.6%) and while the mean of trill accuracy rates was lower in the current study (27.0% as opposed to 35.7%), the sample of trills elicited was more statistically sound, suggesting that the accuracy rate reported in Olsen's study for the beginner participants may have been due to a small sample size. Another important note is that word-initial trills in the current study that are represented as the grapheme <r> do not show a different effect from trills that are represented as the grapheme <rr>. In other words, the more proficient learners understand that word-initial grapheme <r> represents a trilled articulation and not a tap. They have overcome possible L1 orthographic influences discussed by Koda (1989), Munro and Derwing (1994), and Zampini (1994); at least regarding rhotics.

Olsen (2012) found that English rhotic articulation affected trill accuracy among beginning L2 learners. English rhotic articulation also influenced tap accuracy rates for the same learners, but only at the point along the developmental path where learners noticed differences between English rhotics and the two Spanish rhotics. Shortly after this point, English rhotic articulation ceased to be a predicting factor of tap accuracy rates. Results from the current study provide further evidence of this small window where English rhotic articulations affect Spanish rhotic accuracy. The higher proficiency participants in this study have passed the point that English rhotic articulation and small variations in exposure to Spanish affect the accurate pronunciation of either Spanish rhotic. The statistical tests performed on data elicited herein showed no significant effects for English rhotic articulation or exposure to Spanish.

Results from the current study also indicate that perhaps trills follow a similar pattern to taps in that English rhotic articulation may only affect trill accuracy at the emergence of trill production because it was not a predictor of trill accuracy in this study. The effect seen in Olsen (2012) may also have been due to sample size, as previously mentioned. A more robust elicitation text for beginning learners is necessary to flesh out a full account of the physiological effects on trill acquisition to see if they parallel what the results of this study indicates for tap phonemicization.

An important note here is that rankings for prior exposure to Spanish between groups cannot be precisely equated. Although three participants in the current study ranked themselves as having little exposure to Spanish (Likert ranking of 2), it is likely that this ranking matches a ranking of fair or considerable amount of exposure to Spanish (Likert rankings of 4 and 5 respectively) for the participants in Olsen (2012). This proposition is based on the fact that the participants in the current study took a placement test before beginning Spanish study at the university and had either earned a score that placed them in the fourth semester class or had passed previous courses at the university to be enrolled in the fourth semester course. Although Olsen (2012) only indicates that participants were beginners without further specification, learners in a fourth semester course have more experience than 'beginners' because second language acquisition follows a developmental sequence. This insight strengthens the claim that participants in the current study have passed the developmental stage where English rhotic articulation affects Spanish rhotic accuracy. They have spent more time listening to and attempting to produce Spanish rhotics in conversational tasks.

The results of this study concerning the L1 English phonological environment that generates taps show that a significantly high percentage of the accurately produced taps were in words that have stress patterns equal to those that create taps in English. Overall, participants' tap articulations were more accurate when the taps occurred before an unstressed vowel, the phonological environment that generates taps in English. Although a significant difference between English-like phonological environments and other environments was found in the current study, the difference in the means between the two environments was smaller compared to Olsen's (2012) results. The difference between the means of accurate taps in English-like phonological environments (M=77.1) and other environments (M=62.7) in the current study was 14.4 percentage points while the difference between the means of these phonological environments (Ms=61.6 and 45.4 respectively) among participants in Olsen (2012) was 16.2 percentage points. These differences along with the higher means for the fourth semester learners, especially for tap accuracy in other environments, indicate that the fourth semester learners of this study are further along in the phonemicization process but have not fully completed it. Hence, L1 phonological interference continues to be a significant factor of Spanish rhotic accuracy even among learners with intermediate levels of proficiency.

Although trills are not predicted to be influenced by English stress patterns because of the absence of trills in English, a *t*-test was performed to see whether English stress patterns affected trill accuracy. While trill accuracy rates were higher in words with phonological environments equal to those that produce taps in English than in other phonological environments, results showed this difference was not statistically significant. These results indicate that L1 phonological influence only affects the acquisition of the specific phones involved in the L1 phonological representation. They also strengthen the argument that the accuracy of tap production in phonological environments that generate taps in English constitutes an L1 influence and is not simply due to stress patterns relative to rhotic position, also showed by Lewis (2004) with native speakers. The obtained results also support predictions of gestural theories of phonology (Browman & Goldstein 1986). Taps and trills are separate gestural constellations which is why learners do not associate L1 taps with L2 trills. Because the English phonological environment that generates taps can be construed as a specific gesture involving the articulators in the vocal tract, that gesture can be transferred to the same L2 gesture, but not to a different gesture.

As to whether a continuation of the effects found in beginners was evident, results of the current study showed that the influence of L1 articulatory conventions found to be significant at early stages of the acquisition of Spanish rhotics do not persist at more advanced stages. That participants produced significantly more accurate taps in environments identical to those that produce taps in English provides evidence that L1 phonological influence does continue in learners with more language study and experience. These results suggest that while the influence of L1 articulatory routines (a physiological factor) on L2 pronunciation may be overcome with relative ease, the influence of L1 allophonic distribution (a cognitive factor) on L2 pronunciation may persist. One possible explanation for this phenomenon is that articulatory routines in general may be more conscious to learners because they involve muscular activation and physical movement. With practice, new neuromotor sequences can be learned and automatized. Phonological abstractions and rules, on the other hand, are less conscious to learners and are not available for them to consciously improve their L2 pronunciation unless they are explicitly made aware of target phonological rules.

These results have implications for interlanguage phonological theory. The current theories applied to L2 phonological acquisition can partially explain the results obtained in this study in as much as predictions based on perception can be translated to production data. The SLM (Flege 1995) and Best's (1995) Perceptual Assimilation Model (PAM) predict that learners perceive target language segments in terms of existing L1 categories. Best and Tyler (2007) further posit that L2 learners may equate L2 phonemes with their L1 phonemes regardless of the phonetic properties of their allophonic realizations. For L1 English learners of Spanish, this model would predict that Spanish rhotics are assimilated as allophones of English /ɹ/ in the interlanguage system. This type of assimilation is evident among beginners in that they produce [ɹ] instead of taps and trills. That participants in this study were more accurate with taps in environments that produce taps in English suggests that taps are assimilated to a certain extent. This phenomenon implies, however, that assimilation may not be as straightforward as Best and Tyler indicate. English taps are allophones of /t/ and /d/, not of [ɹ]. Since the phonological environment that generates tap production in English also influences tap production in Spanish, assimilation of Spanish rhotics to English rhotics may not be an adequate explanation. The PAM does not account for the application of allophonic properties from an L1 category to an L2 category. The first hypothesis of the SLM, however, may provide an adequate explanation. It states that "sounds in an L1 and L2 are related perceptually to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level" (Flege 1995: 239). Orthographic similarities between English and Spanish rhotics likely combine with this type of allophonic assimilation to strengthen the association of English and Spanish rhotics.

Colantoni and Steele (2008) proposed that L2 phonological acquisition theories should not only address phonological phenomena, but also incorporate phonetic phenomena. The current study shows that phonological influences seem to persist longer than phonetic factors in their influence on accurate production of Spanish rhotics. Although results suggest that phonological rules and representations have greater bearing on the accuracy and sequence of acquisition than articulatory routines, such routines can account for some of the variability among speakers in interlanguage phonology. Therefore, although phonetic constraints should be considered in L2 phonological acquisition, compared to the phonological factors involved in L2 acquisition, phonetic constraints appear to have a lesser influence.

Other implications of this study deal with L2 Spanish learner and teacher expectations. This study has indicated that rhotics are emerging at the beginning levels of L2 Spanish education in a classroom setting. Therefore, teachers should inform students who are often frustrated about the difficulty of pronunciation of the normal developmental process of an L2 phonology involving rhotics. Specifically, teachers could point out the English phonological environment that generates taps and discuss the effect this environment has on Spanish rhotic pronunciation as seen in this study. Teachers should also be aware of the amount of input and practice needed to produce accurate Spanish rhotics reliably. For example, an increase in the number of words containing taps in phonological environments that do not produce taps in English and focused practice sessions on these types of words may reduce the duration of the L1 influence found in this study. Metalinguistic discussions that focus on issues regarding L2 phonological acquisition such as those studied here incorporated into instruction could also help students set personal expectations and goals for attaining accurate rhotic pronunciation.

6. Conclusion

This study has presented some issues in interlanguage phonology of native English speakers learning Spanish. According to Olsen (2012), learners employing a bunched articulation for English rhotics are at a slight disadvantage in producing accurate Spanish rhotics when compared to other learners who employ more retroflex articulations at the initial point when learners begin producing Spanish rhotics. This study provided evidence that differences in phonetic detail between English rhotic articulations have no effect on Spanish rhotic accuracy in leaners with a higher proficiency level. While these L1 phonetic influences are short-lived, L1 phonological influences show a lasting effect and are still evident in the intermediate levels of proficiency. Second and foreign language teachers should also be aware of students' tendencies when acquiring L2 Spanish rhotics to be able to address students' frustrations regarding pronunciation efforts and to have reasonable expectations for their students.

Future research should be carried out to test the possibility of a developmental sequence involving perception, physiological, and production factors using a longitudinal design. Research exploring physiological factors at higher levels of proficiency such as learners who have spent extensive time in countries where the target language is spoken or who have spoken Spanish daily for a long period of time is also needed. Such research may shed light on what dictates why some advanced learners never produce trills although they arguably have acquired separate Spanish rhotic categories. The investigation of other cross-linguistic phonetic and phonological influences may contribute to acquisition, such as differences between articulations of English and Spanish /l/ and /s/ in coda position and the distribution of interdental fricatives, could also provide more evidence of L1 phonetic and phonological influence on L2 phonological acquisition.

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