ASJU, 2023, 57 (1-2), 395-416
https://doi.org/10.1387/asju.25959

ISSN 0582-6152 – eISSN 2444-2992

The acquisition of rhotics in onset clusters in L2 Spanish

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ABSTRACT: This study examines the acoustic realization of rhotics in Spanish onset clusters in 10 native speakers and 25 second language learners (L2) with English as their L1. The comparison of rhotic manner, duration, and svarabhakti vowel occurrence shows partial evidence of English transfer in the L2 group, since fricative, retroflex approximant and coarticulated variants, common in English, account for almost 40% of realizations. Rhotics are also longer in the L2 group and svarabhakti vowels less frequent. Results also show that stop voicing and place of articulation impact rhotic realization in the L2 group. The examination of individual patterns shows that some L2 learners are in initial stages of rhotic acquisition, while others are approaching the native pattern.

KEYWORDS: L2 phonological acquisition; rhotics; taps; approximants; onset clusters.

1. Introduction

One of the areas that most noticeably indicates a foreign accent in Spanish— and that typically causes the most anxiety and difficulty for native English speakers learning this language— is the pronunciation of rhotics ('r', 'rr'). While in Spanish there is a phonemic contrast between the tap and trill (*pero* [pe.ɾo] 'but', *perro* [pe.ro] 'dog'), English only has one rhotic phoneme, an approximant often realized as retroflex, as in *ferry* [fɛ.ɻi] (Hammond 2001; Hualde 2014; Ladefoged & Johnson 2011). Second language (L2) Spanish learners with English as their first language (L1) often struggle with the perception and pronunciation of the tap/trill contrast, which can impact intelligibility and comprehension (see for example Elliott 1997; Hualde 2014: 181-182; Schwegler *et al.* 2007). In addition, a rhotic approximant realization

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How to cite: González, Carolina; Weisglass, Christine (2023). «The acquisition of rhotics in onset clusters in L2 Spanish», *ASJU*, 57 (1-2), 395-416. (https://doi.org/10.1387/asju.25959).

Received: 2022-12-21; Accepted: 2023-03-24.

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in lieu of taps or trills is often noted as one of the most notable marks of a foreign accent in Spanish, contributing to the perception of accentedness.

Thus, it is not surprising that rhotics have been the focus of several acquisition studies for decades (Sacks 1962; Elliott 1997; Lord 2005; Face 2006; Major 1986; Olsen 2012; Reeder 1998; Rose 2010; Scarpace 2014; Waltmunson 2005; Colantoni & Steele 2018). Overall, previous studies show that as Spanish proficiency increases, so does accuracy in rhotic pronunciation and perception, particularly for the tap. Some studies also report that explicit instruction is conducive to improved accuracy, particularly for beginning and intermediate learners (Kissling 2013; Schmeiser 2019).

While most previous research focuses on intervocalic positions—where taps and trills contrast in Spanish—fewer studies examine rhotic acquisition in other contexts. The present study reports a study focusing on rhotic onset clusters (*trato* 'deal', *pronto* 'soon'), which has been investigated to a lesser extent. This study compares rhotic realization in L1 Spanish speakers with intermediate-advanced L1 English, L2 Spanish learners, focusing on rhotic realization, duration, and svarabhakti vowel occurrence. It also addresses segmental factors connected with the preceding stop consonant in the cluster, and investigates individual patterns of rhotic realization in both L1 and L2 Spanish learners.

This paper is organized as follows. Section 2 provides an overview of the distribution, articulation and acoustics of rhotics in Spanish and English. Section 3 introduces the theoretical framework, and section 4 discusses previous studies on the acquisition of onset rhotic clusters in L2 Spanish. Section 5 presents the methodology and section 6 the results of the study. Section 7 discusses our findings, and section 8 provides concluding remarks and points out some directions for further investigation.

2. Spanish and English rhotics: Distribution, articulation, and acoustics

2.1. Spanish rhotics

Spanish has a phonemic contrast between the tap /ɾ/ and trill /r/ word-medially only (*era* 'era', *erra* 's/he errs'). Typically, rhotics are voiced and alveolar, although voiceless and dorsal realizations are attested in some Spanish dialects. Word-initially and after /n/, /s/ or /l/, the trill occurs (*ramo* 'bouquet', *alrededor* 'around', *honra* 'honor', *Israel* 'Israel'). In onset clusters and coda position, the tap occurs most frequently, although other realizations are possible as well (*fresco* 'fresh', *color* 'color') (Blecua 2001; Hualde 2014; Bradley 2020).

The Spanish tap /ɾ/ is pronounced with a fast contact of the tongue tip against the alveolar ridge. Spanish taps average 18-30 ms.; they are characterized by a brief period of silence, occasionally followed by a burst (Blecua 2001; Schmeiser 2019). In some dialects, taps are variably realized as approximants (Blecua & Cicres 2019; Bradley 2020; Hualde 2014: 186; Quilis 1993; Colantoni & Steele 2007). Spanish rhotic approximants are slightly longer than taps (33-45 ms.; Blecua 2001; Weissglass 2015) and are typically alveolar.[1] In Argentinian and Peninsular Spanish, their F3 averages 2,100-2,200 Hz. (Massone 1988; Blecua 2001).

[1] The exception is Costa Rican Spanish, where rhotics are often realized as retroflex approximants; see Salazar (2022) and references therein.

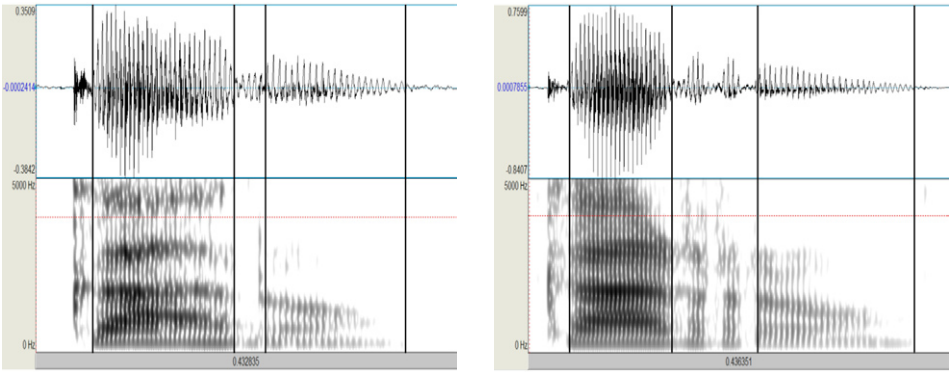

Figure 1

Intervocalic taps and trills

The trill /r/ is the longest Spanish consonant (~85 ms; Quilis 1993). It involves two or more contacts of the tongue tip against the alveolar ridge; acoustically, brief periods of silence alternate with formant structure (Quilis 1993; Hualde 2014: 53-54). Figure 1 exemplifies the acoustic characteristics of intervocalic taps and trills for the minimal pair *caro* 'expensive', *carro* 'cart'.

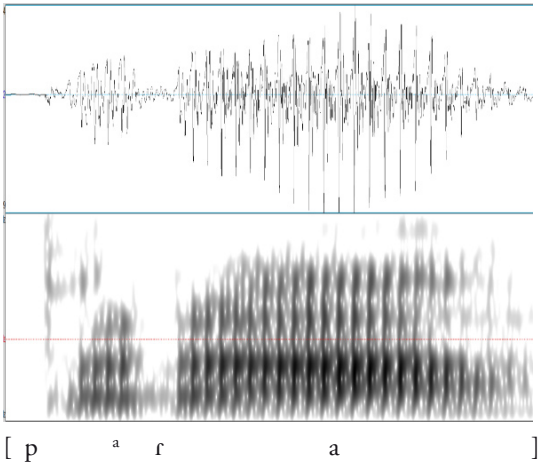

Figure 2

Svarabhakti vowel preceding a tap (6,000 Hz; 30db)

In onset rhotic clusters, Waltmunson (2005: 130-133) indicates that tap realizations average 20 ms; in 85% of cases, taps in this position evidence a burst (see also Colantoni & Steele 2007). In this context, taps tends to be accompanied by

https://doi.org/10.1387/asju.25959

an epenthetic or 'svarabhakti' vowel, i.e., a short, non-nuclear vocalic element with similar formant structure as the nuclear vowel (Figure 2) (Quilis 1993: 337-342; Schmeiser 2006).[2]

2.2. English rhotics

In English there is one contrastive approximant rhotic; it averages 125 ms. intervocalically, but it is shorter (~34 ms.) in onset clusters (Chang *et al.* 2007). The English 'r' tends to involve lip rounding, tongue root retraction, and retroflexion, i.e., the curling back of the tongue tip towards the post-alveolar region (Espy-Wilson 1992; Olive *et al.* 1993: 216). This results in formant lowering, particularly for F3 (below 2,000 Hz, even for females), which is strongly associated with retroflexion (Dalston 1975; Edwards 2003: 208; Olive *et al.* 1993: 98; Reetz & Jongman 2020: 214-215). In addition, American and Canadian English have tap/flap allophones for /t d/ before unstressed syllables ('city', 'adding'; Ladefoged & Johnson 2011; Olive *et al*. 1993: 328-332). English taps are similar to Spanish taps durationally and acoustically (Zue & Laferriere 1979; Reetz & Jongman 2020: 43).

In onset clusters 'r' is often devoiced after voiceless stops ('pry', 'try', 'cry') (Edwards 2003: 205; Cruttenden 2014; Tsuchida *et al.* 2000). After /d/ and /t/, rhotics undergo coarticulation and are usually pronounced as (rhotacized) affricates, particularly after /t/ (examples include 'train' or 'drain'; Carley & Mees 2020: 23; cf. Wells 2011). Unlike in Spanish, svarabhakti vowels are not frequently found in this position (Colantoni & Steele 2007).

2.3. Rhotic taps and approximants: English and Spanish

As discussed above, Spanish and English have rhotic taps with similar acoustic cues (brief period of silence; optional burst; short duration). Rhotic approximants are longer in English, although this difference appears to be minimal in onset clusters. Acoustically, English rhotic approximants are retroflex and have a low F3, unlike in Spanish. Following Ladefoged & Johnson (2011: 176), the Spanish alveolar approximant will be represented with the IPA symbol [ɹ]. On the other hand, the IPA symbol [ɻ] will be used to represent retroflex approximants in English. Both approximant types are distinguished in this study since it is expected that as proficiency increases, L2 Spanish learners will have fewer retroflex approximants, and potentially more alveolar rhotic approximants, since this variant is attested in this context in L1 Spanish.

3. Theoretical framework

Two important aspects involved in L2 phonological acquisition are transfer, i.e, the realization of non-target sounds or sound patterns due to L1 influence, and markedness ('universals' or 'developmental strategies'), relating to the relative fre-

[2] Svarabahti vowels also occur in heterosyllabic rhotic clusters and in coda position in Spanish (Schmeiser 2006, 2019; Real Academia Española 2011: 242).

quency of sounds (and sound patterns). Commonly occurring sounds in the world's languages are unmarked and thus more easily acquired; infrequently attested sounds are assumed to be harder to learn. The question of whether and how transfer and markedness interact in L2 phonological acquisition has been widely discussed (Barlow 2002; Eckman, Elreyes & Iverson 2003; Hecht & Mulford 1982; Peng & Ann 2002; Zampini 1996, 1997). One theory that explicitly addresses the connection between the two is the Ontogeny Phylogeny Model (henceforth, OPM; Major 2001). The OPM states that in early acquisition stages, L1 transfer is pervasive. As proficiency increases, transfer decreases, and the impact of universals increase and then decrease. Key studies on the interaction between transfer and markedness in L2 Spanish rhotic acquisition include Major (1986), Face (2006), Rose (2010), and Waltmunson (2005).

Major (1986) discusses a longitudinal study investigating rhotic acquisition in 4 native English speakers in an intensive beginning-level Spanish course. Participants were recorded during seven weeks reading a word and a sentence list. Approximant rhotics were always coded as transfer errors, and so were taps in positions where trills were expected, since taps are allophonic in English in similar positions. The pronunciation of trills in contexts where taps were expected, and other realizations such as deletions or assimilations were considered developmental errors. Major (1986) found that as proficiency increased, the frequency of transfer errors decreased, with developmental errors becoming more common. With more proficiency increases, accurate pronunciations increased, and developmental errors became less frequent.

Face (2006) investigates intervocalic tap/trill acquisition in 41 L2 intermediate and advanced Spanish learners, including a control group of 5 native Spanish speakers. The task involved reading a short story. For intervocalic trills, intermediate learners evidence transfer (since they realize mostly approximant rhotics), whereas advanced learners have more developmental errors (specifically taps). On the other hand, for the phonemic tap, both groups have a higher proportion of transfer realizations. Face (2006) concludes that results for phonemic trills support the OPM, but that more research is needed regarding the developmental pattern of the tap.

Rose (2010) examines intervocalic tap and trill realizations for 21 L2 Spanish learners at different proficiency levels, including a control group of 6 native Spanish speakers. A picture story task was used to elicit spontaneous data. Lower proficiency learners typically produced taps and trills as English approximants. Intermediate learners pronounce taps mostly accurately, but variably produce Spanish trills as taps, approximants or other continuants. Advanced learners overgeneralize taps to phonemic trill contexts. Finally, learners with the highest proficiency (graduate students in Spanish) tend to realize intervocalic taps and trills accurately.

Waltmunson (2005) investigates the realization of rhotics (and dental stops) in L2 Spanish. He reports results two experimental studies with L2 Spanish learners at different proficiency levels; the first study includes 23 participants, and the second 21. Eleven native Spanish speakers were also recorded (5 in the first study and 6 in the second). Participants read sentences containing target words. The contexts investigated included word-medial taps and trills in addition to word-initial and onset rhotic contexts. Waltmunson distinguishes taps (with a release burst), perceptual

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taps (without), and approximants. Other realizations included voiced stops, trills, and perceptual trills (sounding like trills but lacking clear acoustic cues).

Word-medially, L1 Spanish speakers realize phonemic taps as taps in 99% of cases. L2 learners show increased accuracy of taps as proficiency goes up, except for intermediate learners, which show the highest proportion of approximants. Although Waltmunson's results are in line with the OPM overall, intermediate learners appear to be regressing, at least temporarily, in their acquisition of word-medial taps. The following section will further discuss this work in connection with rhotic onset clusters.

4. Studies on onset rhotic clusters in L2 Spanish

The L2 acquisition of Spanish onset rhotic clusters (*primo* 'cousin', *otra* 'another one') is relatively under-investigated. Exceptions include Major (1986), Waltmunson (2005) and Hurtado & Estrada (2010), comparing rhotics in various contexts, and Colantoni & Steele (2007, 2018), focusing on clusters.

Major (1986), introduced in the previous section, investigates the acquisition of rhotics word-initially, medially, syllable-finally, and after consonants in beginning L2 Spanish. Major (1986) found rhotic manner accuracy to be highest for taps word-medially; after consonants, three learners evidenced English transfer, while the remaining participant showed increased accuracy and developmental pronunciations. Some drawbacks of this study include a small number of participants, the lack of a native control group, and not distinguishing between onset clusters and heterosyllabic contexts (such as *carta* 'letter'). In addition, Major (1986) does not include acoustic analysis.

The study in Waltmunson (2005), introduced above, also considers rhotic onset clusters. L1 Spanish speakers pronounce taps in 85% of clusters and perceptual taps in 15%. They also show SVs in 85% of cases. As Spanish proficiency increases, L2 learners increase in rhotic accuracy in clusters, except for intermediate L2 learners (Table 1). SVs emerge consistently in advanced L2 learners. The author notes that word-medial rhotics are acquired before those in onset clusters (Waltmunson 2005: 237, 245).

Table 1

Rhotic onset cluster realizations (adapted from Waltmunson 2005: 229)

Level	Tap	Approximant	Perceptual tap	Perceptual trill	Voiced stop	SV
Beginner	10%	68%	11%	11%	1%	1%
Intermediate	4%	88%	13%			1%
Advanced	45%	26%	12%	4%	9%	21%
Experienced	69%	11%	15%	3%	2%	59%
L1 Spanish	84%	4%	11%			85%

Hurtado & Estrada (2010) investigate Spanish rhotics in 37 L2 learners enrolled in a Spanish pronunciation class. They include syllable-initial, codas, and onset clus-

ters. Participants were recorded at the beginning and at the end of the course. Tasks included reading isolated words, phrases and texts, and answering questions including target words representing various levels of frequency. The authors consider [ɪ] to be the only non-target realization for Spanish 'r', 'rr' since rhotics are variable across Spanish dialects.

Results revealed that L2 learners produced retroflex approximants in 55% of tap contexts; trills were also common. L2 learners achieved the most target-like pronunciation syllable-initially (61%), and the least in coda (34%). In onset clusters, accuracy was achieved in 46% of cases. Stop place influenced rhotic realization, with target-like realizations being particularly favored by velars (56%) (bilabials: 48%; alveolars: 42%).

Colantoni & Steele (2007) examine stop and rhotic voicing, rhotic duration and manner, and the occurrence and duration of svarabhakti vowels (SV) in onset clusters. Data from 10 L2 Spanish participants (5 intermediate and 5 advanced) was compared to a control group of 10 Argentinian Spanish speakers. Data was gathered from a word list and a short passage. L2 participants showed longer rhotic duration than the native Spanish group, particularly for intermediate learners. L2 Spanish learners favored approximant realizations, unlike the L1 group. Only advanced learners produced SVs as often as native Spanish speakers, especially after voiced stops. The authors argue that rhotic manner and SV were acquired to a lesser extent in the L2 Spanish group than stop voicing or duration, since the former vary more widely in L1 Spanish. Colantoni & Steele conclude that only one learner had attained all the phonetic properties relevant for Spanish stop-rhotic clusters.

The connection between input variability and the acquisition of the phonetic characteristics of stop-rhotic clusters is further explored in Colantoni & Steele (2018). This study includes 19 L2 Spanish learners (9 intermediate, 10 advanced) and a control group comprising 10 Argentinian and 10 Chilean Spanish speakers. Stimuli were embedded in carrier sentences. Results show that L1 Spanish participants produced taps in 93% of cases after voiceless stops, and in 98% after voiced ones; other realizations were fricative. For L2 Spanish learners, accuracy was higher after voiced stops for rhotic manner, particularly if they had advanced proficiency.

None of the studies discussed above recognize approximant realizations as potentially native like, despite evidence that approximant rhotics occur in L1 Spanish (Martínez Celdrán & Fernández Planas 2007: 157; Blecua 2001; Weissglass 2015). Thus, it is likely that some of the approximant realizations previously reported for L2 learners are not due to English transfer. In addition, some of these studies lack a Spanish control group or include only L1 Spanish speakers from one dialect. Because rhotics in Spanish have a wide range of realizations, this makes it hard to assess whether some of the rhotic realizations reported for L2 Spanish in onset clusters are target-like.

The present investigation departs from previous studies on rhotic onset clusters in three respects. First, it includes a native Spanish control group representing a variety of dialects. Second, it focuses on nonce words to ensure that word frequency and word familiarity does not influence rhotic realization. Nonce words also facilitate the examination of stop place and voicing, since there are not minimal pairs for all stop contrasts in onset rhotic sequences. Third, it distinguishes between alveolar and ret-

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roflex approximants to tease out whether transfer always accounts for approximant variants in L2 Spanish.

5. Methodology

5.1. Participants

Participants included 25 native speakers of English (5 males and 20 females) enrolled in two different sections of a third-year university-level course on Spanish grammar and writing; they were 20 years old on average. The course participants were enrolled in was taught by the same instructor, who, to avoid potential bias, was not part of the investigation. Only four participants had spent five or more months in a Spanish speaking country. Participants were interviewed once at the beginning of the semester, and once at the end. After agreeing to participate in writing, they performed the following tasks during each interview session: a pronunciation task, a perception task, and a grammar test. The grammar test included 10 questions and was used to divide participants into three proficiency levels (low: 0-4; mid 4.1-7; high: 7.1-10). More information about individual proficiency will be discussed in section 6.[3]

A control group of 10 native Spanish speakers was also included to establish a baseline for what constitutes native-like production of stop-'r' clusters in Spanish. This control group included speakers from diverse dialectal areas to capture a wide variety of L1 rhotic realizations (Table 2). The average age of L1 participants was 35 years. All had English as their L2 and spoke Spanish daily with their families and at work.

Table 2

L1 Spanish participants

Speaker	Country	Age	Years in USA
N1	Cuba	39	6
N2	Bolivia	30	7
N3	Colombia	34	4
N4	Peru	42	3
N5	Mexico	33	8
N6	Spain	25	3
N7	Argentina	31	3
N8	Venezuela	21	
N9	Argentina	38	13
N10	Puerto R.	55	40

[3] Half of the participants received pronunciation instruction for 10 minutes weekly on vowels, vowel sequences, stress, and consonants. Because instruction did not include rhotics in onset clusters, and the stimuli for this part of the study was only included in the post-test, we will not address here the potential effect of instruction on the acquisition of these clusters.

5.2. Stimuli and data collection

Stimuli included a minimal set of six nonce words with stop-rhotic clusters (Table 3). All target words were disyllabic, with open syllables, word-initial stress, and a stop-rhotic cluster at the beginning of the first syllable. The stop rhotic cluster varied in voicing and place of articulation.

Table 3

Tokens

	Bilabial	**Dental**	**Velar**
Voiceless	prafa	trafa	crafa
Voiced	brafa	drafa	grafa

Nonce words were used to ensure that neither word frequency nor lexical familiarity impacted rhotic realization. Stimuli were integrated into a list of words read twice by all participants.

Participants were recorded in the phonetics lab at Florida State University using a Marantz Professional Portable Solid-State Recorder (Model PMD660) and a high-quality AKG cardioid condenser microphone (Model C 1000 S) with a Presence Boost Adapter (PB 1000). Data was recorded in .wav (sampling rate: 44,100 Hz.). Interviews were conducted in Spanish by both authors. Each participant produced 12 tokens (6 tokens × 2 repetitions). A total of 420 tokens (12 tokens × 35 speakers) was analyzed acoustically in *Praat* (Boersma & Weenink, 2012).

5.3. Acoustic and statistical analysis

Data was analyzed primarily by the second author; the first author double-checked 10% of the data. Coding disagreements were few and were solved by consensus. The dependent variables investigated were rhotic manner, rhotic duration, and SV occurrence.

5.3.1. Rhotic manner

The following rhotic variants were attested in our data: taps, trills, fricatives, coarticulation, deletion, and approximants. Taps were characterized by a short period of silence optionally followed by a burst. Trills showed an alternation of two or more closures and short vocalic phases. Figure 3 provides examples of both; [r] is preceded by a SV.

Fricatives were characterized by noise in the mid/upper frequencies of the spectrogram. Coarticulated variants occurred when the preceding stop had a long VOT, obscuring its acoustic cues despite a clear auditory rhotic impression. After a dental stop, coarticulation often resulted in affricate realizations. Examples of fricatives and coarticulation are shown in Figure 4. Rhotics with no clear acoustic and auditory rhotic cues were analyzed as deleted outcomes (Figure 5).

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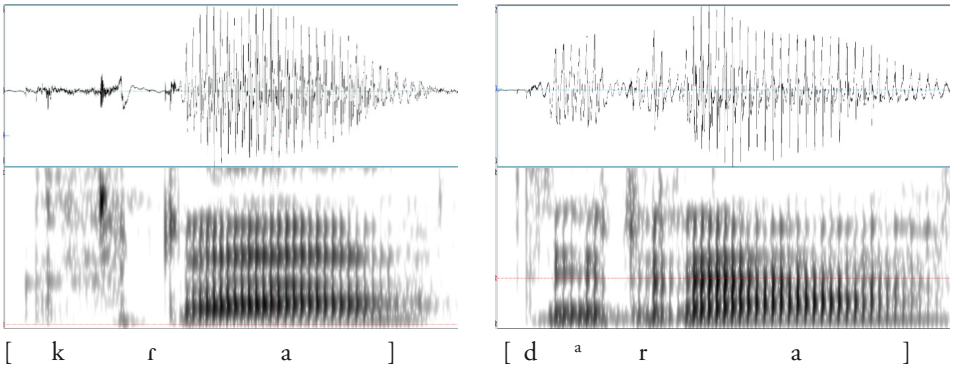

Figure 3

Tap and trill in onset clusters (6,000 Hz)

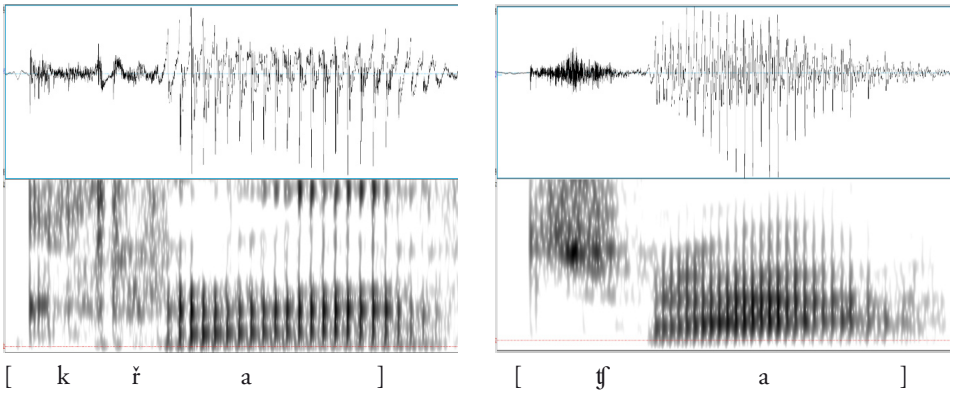

Figure 4

Fricative and coarticulated variants (6,000 Hz)

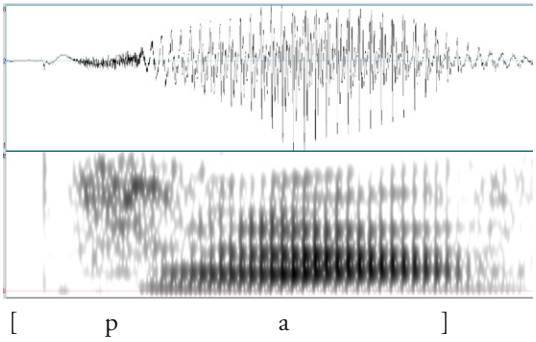

Figure 5

Deleted 'r' in 'prafa' (6,000 Hz)

Approximant rhotics exhibited low amplitude formant structure. Alveolar approximants had an F3 above 2,000 Hz, and retroflex approximants below. Examples appear in Figure 6.

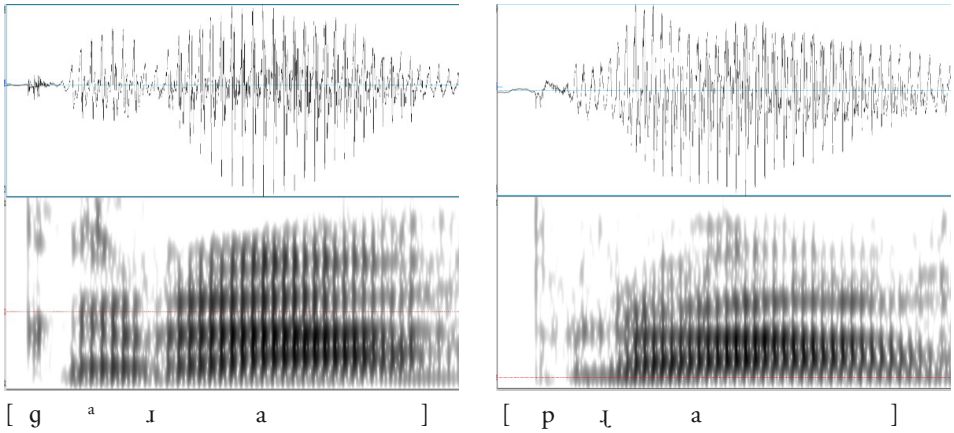

Figure 6

Alveolar and retroflex approximants (6,000 Hz)

5.3.2. Svarabhakti vowels

SVs exhibited strong high-amplitude formant structure between the stop and the rhotic (Figures 1, 3, 6). SV duration was measured from the end of the stop to the onset of the rhotic (Blecua 2001; Martínez Celdrán & Fernández Planas 2007; Ramírez 2006).

5.3.3. Rhotic duration

Rhotic duration was measured from the end of the stop or SV, when present, to the onset of the nuclear vowel (Blecua 2001).

5.3.4. Statistical analysis

Pearson's Chi-square tests were performed for categorical data and single-factor ANOVAs for continuous data using *IBM SPSS Statistics 21.0* (IBM Corp. 2012). Results are significant if $p < .05$.

5.4. Hypotheses

The main hypotheses investigated in this study are listed below:

(i) L2 Spanish learners will differ from L1 Spanish participants in rhotic manner, duration, and/or frequency of SV occurrence.
(ii) Stop place and voicing will influence rhotics realization in L2 Spanish.
(iii) L2 learners with higher Spanish proficiency will show higher rhotic accuracy compared to learners with lower Spanish proficiency.

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5.4.1. Hypothesis 1

L1 Spanish participants will show a preference for taps and alveolar approximants. If transfer from English is a dominant factor at the intermediate-advanced level, L2 Spanish learners will pronounce retroflex approximants, fricatives, and/or coarticulated variants. Because these rhotic variants tend to be long, it is expected that rhotics will be longer in the L2 Spanish group. Few SVs are expected in the L2 group.

5.4.2. Hypothesis 2

Stop voicing and place will impact rhotic manner in the L2 group. Voiceless stops are conducive to rhotic fricative realizations in English clusters; under transfer, a similar pattern is expected in L2 Spanish. Similarly, /d/, /t/ frequently lead to rhotic coarticulation, a pattern also expected to be transferred to L2 Spanish. Because fricatives and coarticulated variants are long, rhotics are predicted to be longer after voiceless stops and /d/, /t/. SVs are expected to be more frequent after voiced stops in the L2 group.

5.4.3. Hypothesis 3

Low-proficiency L2 learners are expected to have more rhotic realization consistent with transfer, longer rhotic durations, and fewer SVs. High-proficiency L2 learners are expected to approximate the L1 group pattern, i.e., to have more taps/alveolar approximants, shorter rhotic durations, and a higher incidence of SVs.

6. Results

6.1. Overall results

In the L1 group, 51% of tokens were realized as approximants, and 37% as taps. Trills and fricatives were rare and there were no coarticulated or deleted outcomes. In comparison, in the L2 group taps comprised 33% of all tokens, followed by approximants (28%). Fricative and co-articulated variants occurred in 19% and 17% of tokens, and trills and elision were rare (Table 4).

Table 4

Rhotic manner

Rhotic manner	L2 Spanish		L1 Spanish	
	N	%	N	%
[ɾ]	98	33%	44	37%
Coarticulation	52	17%		
Fricatives	56	19%	6	5%
[ɹ]	85	28%	61	51%
[r]	8	3%	9	7%
Deletion	1	< 1%		
Total	300	100%	120	100%

Approximants had a lower F3 in L2 Spanish (F3 average for L1: 2,553; range: 1,919-3,215 Hz.; F3 average for L2 Spanish: 2,457 Hz; range: 1,608-3,043 Hz.; Figure 7). 12% of all approximants in the L2 group (3% of all rhotic realizations) had a low F3 consistent with retroflexion; only one token in the L1 group can be considered retroflex.

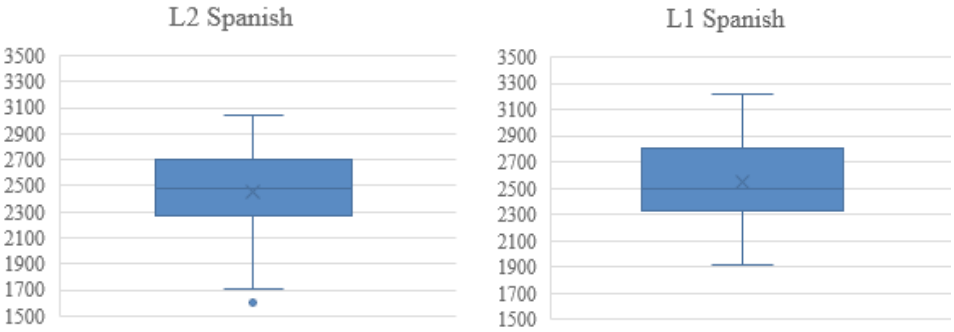

Figure 7

F3 in L1 and L2 Spanish

Rhotics averaged 25 ms. in the L1 group and 42 ms. for L2 learners. Trills were the longest variants in the L1 group (Table 5). Fricatives were longer than approximants, and approximants than taps. In the L2 group, the longest variants involved coarticulation, followed by trills. Fricatives, approximants and taps had comparable durations. Across groups, the average duration and range of trills and alveolar approximants are practically identical.

Table 5

Rhotic duration (in ms.)

Rhotic manner	L2 Spanish		L1 Spanish	
	Average	Range	Average	Range
[ɾ]	24	11-45	19	9-32
[ɹ]	24	13-48	26	14-49
[ɻ]	30	15-61		
Coarticulation	94	22-186		
[r]	52	31-59	51	29-60
Fricatives	25	13-59	28	20-40

SVs occurred in 89% of cases in the L1 group, but in 60% in the L2 group. SVs averaged 30 ms. in the L1 group (range: 9-65 ms.) and 29 ms. in the L2 group (range: 6-146 ms.).

Results partially support Hypothesis 1. The L2 group has rhotic variants consistent with transfer in 39% of tokens; other realizations are native-like. Durationally,

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rhotics are longer in the L2 group, consistent with the longer overall intrinsic duration of fricatives and coarticulated variants compared to taps and alveolar approximants. Both groups had SVs in most cases, particularly in the L1 group, as hypothesized.

6.2. Stop voice and place

6.2.1. Stop voicing

Stop voicing did not impact on rhotic manner, duration, or SV occurrence in the L1 group. In the L2 group there were more approximants and trills after voiced stops (79%, 88%, respectively), and more fricatives and coarticulation after voiceless stops (71%, 96%, respectively; $\chi^2 = 89.154$, $p < .001$). As shown in Table 6, rhotics in the L2 group were twice as long after voiceless stops than after voiced stops; this pattern was significant ($F(1, 297) = 54.048$, $p < .001$). SVs were three times as common in the L2 group after voiced stops than after voiceless stops ($\chi^2 = 78.346$, $p < .001$).

Table 6

Stop voicing: Duration and SVs

	L1 group		L2 group	
	Voiced stop	**Voiceless stop**	**Voiced stop**	**Voiceless stop**
Duration	27 ms.	25 ms.	26 ms.	51 ms.
SVs	93%	88%	71%	29%

6.2.2. Stop place

Stop place did not significantly impact rhotic manner in the L1 group; taps and approximants had a similar frequency of occurrence regardless of stop place of articulation (Figure 8). Fricatives were more prevalent after dentals, and not attested after velars; while trills were more common after bilabials, and least common after dental stops. However, because of the low incidence of fricative and trill realizations in the L1 group, these patterns were not statistically significant.

In the L2 group, stop place had a significant impact on rhotic manner for fricatives only, which were more prevalent after dental stops ($\chi^2 = 22.428$, $p = .013$). As shown in Figure 9, taps and approximants were slightly more prevalent after bilabial stops; coarticulated variants were somewhat more common after dental and velar stops; and trills were more frequent after bilabial stops. Nevertheless, these differences were not significant.

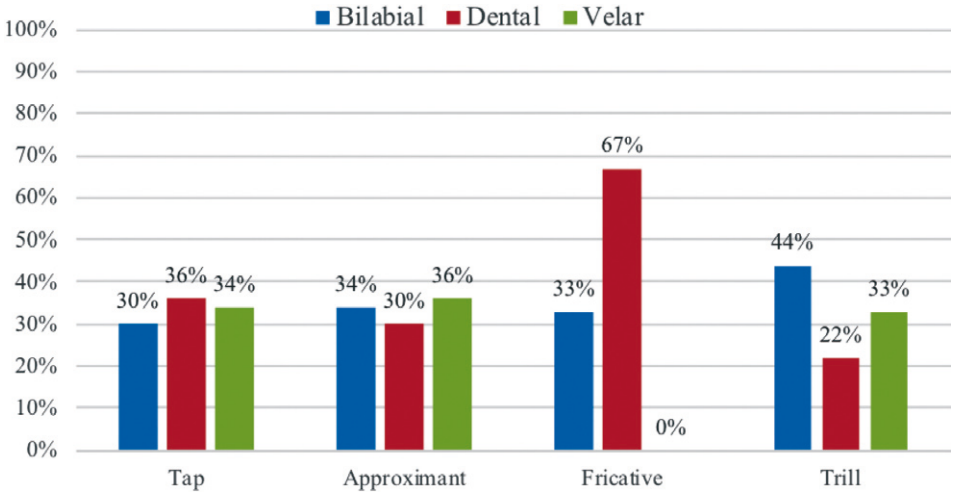

Figure 8

Stop place: L1 rhotic manner

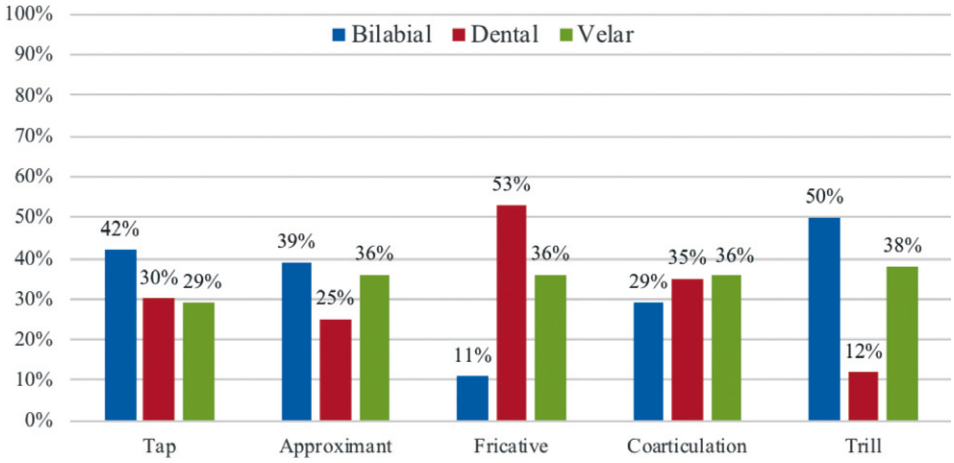

Figure 9

Stop place: L2 rhotic manner

As shown in Table 7, rhotics were shorter but not significantly so after dental stops in the L1 group. In the L2 group, rhotics were significantly longest after velars (F (2, 296) = 3.097, p = .047). No significant differences were found for SV occurrence in either group.

https://doi.org/10.1387/asju.25959

Table 7

Stop place: Duration and SVs

	L1 Spanish			L2 Spanish		
	Bilabial	**Dental**	**Velar**	**Bilabial**	**Dental**	**Velar**
Duration	28 ms.	23 ms.	27 ms.	32 ms	38 ms.	43 ms.
SV	85%	95%	88%	35%	34%	31%

Results partially support hypothesis 2; stop voicing has a significant effect on rhotic manner, duration and svarabhakti vowel occurrence in the L2 group, unlike in the L1 group, and place of articulation significantly impacts rhotic manner and duration in the L2 group.

6.3. Individual variation

Table 8 shows that half of the L1 Spanish participants had mostly taps in onset clusters, and four mostly alveolar approximants. One participant, from North-Central Spain, had mostly trills. Participant N8 had fricative realizations in a third of cases.

Table 8

L1 Spanish: Individual variation in rhotic manner

	Taps	**Approximants**	**Fricatives**	**Trills**
N1	67%	33%	—	—
N2	83%	17%	—	—
N3	—	100%	—	—
N4	17%	83%	—	—
N5	—	100%	—	—
N6	33%	—	—	67%
N7	50%	33%	8%	8%
N8	58%	8%	33%	—
N9	—	100%	—	—
N10	58%	33%	8%	—

Table 9 lists individual results for rhotic manner in the L2 group; relative proficiency (L[ow], M[id], H[igh]) is indicated next to the participant number; a star (*) indicates if they spent five or more months in a study abroad program in a Spanish-speaking country. Proficiency did not influence rhotic manner; however, the four L2 learners who had spent five or more months in a Spanish-speaking country signifi-

cantly had fewer fricative rhotics than those who had not (6% vs. 19%; $\chi^2 = 14.419$, df = 5, $p = .013$). Study abroad did not otherwise impact rhotic realization.

The examination of individual variation regarding rhotic manner and SV occurrence in the L2 group suggests three different acquisition stages. The most advanced stage comprises ten L2 learners (40% of L2 participants, indicated with dark gray shading) with mostly taps and/or alveolar approximants. These learners had SVs in at least 50% of cases. An intermediate stage comprises four L2 learners (16% of L2 learners, indicated with light gray shading), with a frequency of fricative/coarticulated variants much higher than in the L1 group. The remaining eleven participants (44% of the dataset) mostly pronounced retroflex approximants, fricatives, and/or co-articulated variants; SV occurrence ranges from 17% to 83% in this group.

Table 9

L2 Spanish: Individual variation in rhotic manner and SV

	[r]	[ɹ]	[ɻ]	Fricative	Coarticulation	[r]/other	SV
L1 (M)	58%	17%		25%			58%
L2 (M)*	58%	25%		17%			67%
L3 (M)	41%	17%		25%	17%		75%
L4 (M)*	17%	41%		17%	17%	8%	75%
L5 (L)	25%	8%	8%	33%	25%		58%
L6 (H)	67%	8%		25%			67%
L7 (H)*	25%	17%	8%	42%		8%	33%
L8 (M)		33%	17%	33%	17%		83%
L9 (L)		8%	25%	8%	59%		33%
L10 (L)	67%	25%			8%		75%
L11 (H)	50%	33%			17%		75%
L11 (H)	25%	17%	8%	8%	42%		42%
L13 (L)	41%	25%		17%	17%		50%
L14 (L)	50%	50%					67%
L15 (H)	42%	8%		17%	25%	8%	17%
L16 (L)	33%	17%		42%	8%		75%
L17 (L)	67%			17%		17%	100%
L18 (M)	25%	25%		50%			58%
L19 (M)	8%	8%		33%	17%	33%	67%
L20 (L)*	8%	8%	42%	0%	33%	8%	25%
L21 (L)	25%	50%		8%	17%		75%
L22 (H)	25%	33%		33%	8%		50%
L23 (H)	8%	59%	17%	8%		8%	83%
L24 (M)	8%		17%	17%	58%		17%
L25 (H)	42%	17%		33%	8%		83%

https://doi.org/10.1387/asju.25959

7. Discussion

L1 and L2 participants differ in their rhotic pronunciation in Spanish onset clusters, as hypothesized. Both groups overall show a preference for tap and approximant realizations, but the L2 group has 39% of realizations consistent with English transfer, including fricatives, coarticulation, and retroflex approximants. Rhotic duration in onset clusters was significantly longer in the L2 dataset than the native group, and SV occurrence less frequent. These results fall along the lines of Colantoni & Steele (2007, 2018) and Waltmunson (2005), although they show that alveolar approximants are attested for L1 Spanish speakers to a larger extent.

It was also hypothesized that stop place and voicing would influence rhotic realization in the L2 group. Stop voicing influenced rhotic manner and duration in this group as expected, since fricatives and coarticulation were significantly longer and more frequent after voiceless stops. SVs were also significantly less common after voiceless stops. Results suggest that learners acquire (or approximate) native rhotic realization patterns after voiced stops first; but that rhotic duration, manner and SV realization patterns after voiceless stops arise from English transfer. These results are along the lines of those reported for rhotic manner and voicing in Colantoni & Steele (2018).

For stop place of articulation, L2 learners have longer rhotic duration after velars and more fricative realizations after dentals. These results were not expected but might be consistent with English transfer. The greater likelihood of fricative rhotics after dentals might result from long VOT values in this context. Indeed, for English, Edwards (2003: 76, 88, 100) reports a VOT of 93 ms. for /tɹ/, longer than for /kɹ/ (84 ms.) or /pɹ/ (59 ms). The percentage of fricative realizations in the L2 group is consistent with these VOT values, since 11% of fricatives occur after /p/, 37% after /k/, and 52% after /t/.

Proficiency had no effect on rhotic realization in the L2 dataset; immersion in Spanish-speaking countries impacted the likelihood of fricative realizations. However, the comparison of individual rhotic patterns in the L1 and L2 groups provide a more nuanced view of rhotic realization in L2 Spanish. Almost half of the L2 learners in the study evidence an early interlanguage stage mostly characterized by English transfer. A few learners show a decrease of transfer and an increase of accurate rhotic realizations; while 40% of learners can be considered to have acquired, or to be very close to acquiring, the target L1 rhotic patterns.

8. Conclusion

The present study examined the acoustic realization of rhotics in onset clusters in L2 Spanish. Our investigation diverged from previous studies since it focused on nonce words and included a control group of native Spanish speakers from varied dialects. However, results are overall comparable to those reported in previous studies, in particular Colantoni & Steele (2007, 2018), and Waltmunson (2005). Segmental factors, in particular stop voicing and place, significantly impact rhotic manner, duration and SV occurrence in L2 Spanish, unlike in L1 Spanish; and shows that acquisition that rhotics is achieved first in voiced onset clusters. Three different acqui-

sition stages were identified, characterized by a decrease in transfer and an increase in accurate rhotic realizations as learners approximate native Spanish rhotic patterns.

One of the contributions of this study is the examination of F3 to tease out retroflex approximants, likely resulting from English transfer, from alveolar ones, common in various Spanish dialects. Few retroflex approximants were attested, but it is expected that they will be more frequent in beginning Spanish learners. Another contribution is the inclusion of L1 Spanish speakers from varied dialects. The L1 patterns documented here suggest that 'developmental rhotics' might be better reanalyzed as alternative rhotic realizations across Spanish dialects.

Some of the limitations of this study include a relatively small number of tokens and a simple reading task. Future studies will benefit from including a larger number of tokens and additional tasks. The inclusion of native Spanish speakers from other dialectal areas not considered here, including Costa Rica Spanish, where approximant and fricative rhotic realizations are common in onset clusters, will also shed additional light on the differences between L1 and L2 rhotic realization.

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