Native-Like Attainment in the L2 Acquisition of Spanish Stop-Liquid Clusters

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1. Native-like attainment and L2 phonetics

It is often claimed that native-like pronunciation is impossible in non-primary language acquisition (e.g., Scovel 1988, Long 1990). A number of recent studies, however, have refuted this claim (Bongaerts et al. 2000, Birdsong 2003). This research argues that, at least for some phonetic properties, second language (L2) learners' production may not differ significantly from that of native speakers.

In this paper, we provide further evidence that L2 learners may achieve native-like mastery of target language phonetic properties. Moreover, we propose that the relative difficulty of acquisition can be predicted based on the variability characterizing the properties in question. Specifically, the greater the degree of variability in the phonetic realization of a given parameter, the more difficult it will be to acquire. The data to be discussed come from an experimental study of the acquisition of Spanish stop-liquid (SL) clusters by adult native speakers of English. SL clusters provide an interesting challenge for such learners. While their phonology and orthography are highly similar in both languages, Spanish SL clusters differ vis-à-vis their English counterparts as concerns stop voicing, rhotic manner, and the presence of cluster-medial epenthetic vowels with rhotics. As native-like acquisition requires the mastery of not one but rather multiple phonetic parameters, the data examined here provide evidence that native-like attainment of phonetics is possible in L2 acquisition, albeit rarely and only with a small subset of learners.

The remainder of the paper is structured as follows. In §2, we outline the phonetic parameters along which English and Spanish differ as concerns the realization of SL clusters. This includes discussion of previous research that has demonstrated the presence of epenthetic vowels in rhotic clusters. The experiment undertaken to determine whether English-speaking learners can acquire such differences is outlined in §3. In §4, we present the results of the acoustic analysis of the learner data and evaluate the hypotheses made in §3 for stop voicing, rhotic manner, epenthesis, and overall attainment. We conclude in §5 with discussion of differences in attainment of the various phonetic properties under investigation. This includes consideration of the difficulty represented by both intra and interspeaker variation in the input for L2 learners.

2. Stop-liquid clusters in English and Spanish

Both English and Spanish permit stop-liquid clusters, as shown in (1) below.

(1) English and Spanish stop-liquid clusters

a. English		b. Spanish		
supply	/sʌplaj/	*sopla*	/sopla/	's/he blows'
treaty	/tɹiti/	*traté*	/tɾate/	'I tried'

While such clusters are alike orthographically and phonologically—they syllabify as branching onsets in both languages and are subject to similar phonotactic constraints including a prohibition on

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tautosyllabic coronal+lateral sequences—as mentioned earlier, there are differences in their phonetic realization. These differences will be the focus of the following sections.

2.1 Stop voicing

In English, the phonemic voiceless-voiced contrast in word and stressed syllable-initial stops is realized as one between long and short lag counterparts (e.g., Lisker & Abramson 1964).[1] Spanish, typical of Romance, uses rather a short lag-prevoiced contrast (e.g., Lisker & Abramson 1964, Borzone de Manrique & Gurlekian 1980, Quilis 1993).

2.2 Rhotic

The second difference between the two languages concerns the phonetic realization of <r>. Whereas both languages possess a coronal rhotic, the rhotics differ in manner. In English, <r> is realized as the approximant [ɹ]. In some voiceless clusters, it may be affricated; this is particularly true following [t]. In Spanish, the rhotic is the tap [ɾ].[2] Note that [ɾ] is an allophone of /t/ in North American English (e.g., *butter* /bʌtəɹ/→[bʌɾ̟ɹ]), the first language of the learners tested here.

2.3 Epenthesis in Spanish stop-liquid clusters

English SL clusters are realized as phonetically uninterrupted sequences (see §4.1). In contrast, Spanish SL clusters often involve an epenthetic vowel.[3] Colantoni & Steele (In press), building on previous work (Malmberg 1965, Quilis 1970, 1993), undertook an experimental investigation of the phonetics of Spanish and French obstruent-liquid clusters. The Spanish data were elicited from 11 Argentinean speakers (5 male; 6 female) via a word-reading task.[4] As concerns the stop-liquid clusters of interest here, virtually no epenthesis was observed in lateral clusters. In stark contrast, the majority of tokens containing a rhotic involved a cluster-medial epenthetic vowel.

Cluster	# Epenthetic forms	Total # forms	% Epenthesis
Stop + /l/	9	595	**1.5**
/p,t,k/ + /ɾ/	339	360	**94.2**
/b,d,g/ + /ɾ/	386	395	**97.7**

Table 1: Epenthesis in Spanish stop-liquid clusters (Colantoni & Steele In press)

The waveforms and spectrograms in Figures 1 and 2 (overleaf) are typical of the Argentinean data and demonstrate the presence of the epenthetic vowel in both voiceless and voiced tokens respectively; the vowel is highlighted by the dotted box. In summary, the data from Colantoni and Steele (In press) are characterized by a strong lateral-rhotic asymmetry, with virtually no epenthesis in lateral clusters versus quasi-categorical epenthesis in their rhotic counterparts. Other variables, including stop place, position of the cluster in the word and stress, were also found to condition epenthesis, although with significantly less weight; these variables will not be investigated with the L2 learners here.

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[1] Variation is attested. For example, Keating (1984) reports prevoicing in some medial stops.

[2] The tap is the standard variant used by the control group in the present experiment. There is, however, variation in the realization of <r>. In some varieties, it is realized as a fricative (see Navarro Tomás 1970). Blecua (2001) found a small percentage of approximant realizations in Peninsular Spanish, an otherwise tap-variety.

[3] The term 'epenthesis' is used here as in Colantoni and Steele (In press) to designate a purely phonetic process. Indeed, the vowels in question are not characterized by the properties typically associated with phonological epenthetic vowels (see e.g., Hall 2003, Bradley In press).

[4] Colantoni and Steele's (In press) Argentinean speakers will serve as controls for the acquisition study to be presented in §3. The values for stop voicing come from another paper by the same authors (Colantoni & Steele 2004), which presents data from 10 of the 11 original speakers. As the L2 learners' production will be analysed for voicing among other properties, the control group will consist of the 10 speakers analysed in Colantoni and Steele (2004).

One final characteristic of the data will be relevant to the acquisition study to be discussed in the remainder of the paper. As concerns the epenthetic vowel itself, mean length ranged from 31-40 ms for 8 of the 11 speakers tested. Moreover, the vowel was longer in voiced environments. These findings concerning epenthesis for the Argentinean speakers are consistent with those found for European varieties (Quilis 1970 and Blecua 2001 for Madrid and Barcelona Spanish respectively).[5]

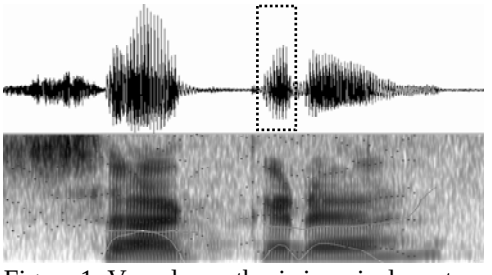

Figure 1: Vowel epenthesis in voiceless stop-rhotic cluster *sacra* /sakɾa/ 'sacred'

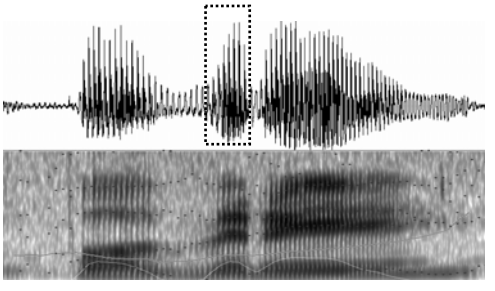

Figure 2: Vowel epenthesis in voiced stop-rhotic cluster *podré* /poðɾe/ 'I will be able to'[6]

3. Experiment

In order to determine whether English-speaking learners can acquire the phonetic properties of the stop-liquid clusters discussed immediately above, the experiment described in Colantoni & Steele (In press) was replicated with a group of 10 Intermediate and Advanced English-speaking learners.

3.1 Hypotheses

Following Bongaerts et al. (2000) and Birdsong (2003), we predict that at least some very advanced learners will be able to master all three aspects of the SL clusters given sufficient exposure to native-speaker input. The Advanced learners tested for the present study were required to have spent a minimum of six months in a Spanish-speaking milieu; all of them had spent at least one year. We assume that such exposure is sufficient. Beyond this general hypothesis, we also make predictions for developmental sequences, that is, for the performance of the Intermediate versus Advanced learners. These predictions are outlined below.

3.1.1 Hypotheses regarding stop voicing

Previous studies, including Birdsong (2003), have demonstrated that L2 learners can master target voicing contrasts, including VOT properties. As such, we predict that the majority of Intermediate learners will master the Spanish short lag-prevoiced contrast. Following our general hypothesis, we predict native-like performance for the Advanced learners.

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[5] Epenthesis should be found in all varieties with the exception of those having affrication in coronal-rhotic clusters (e.g., Chilean varieties - Lenz 1940, Alonzo 1953; Ecuadorian Spanish - Bradley 1999).

[6] Voiced stops may be realized as approximants, as is the case here.

3.1.2 Hypotheses regarding rhotic clusters

As stated above, English has [ɾ] phonetically, but only in intervocalic position. Indeed, stop+stop sequences are prohibited syllable-initially. Given the strong influence of L1 phonetic transfer even at intermediate stages of acquisition, we consequently predict direct substitution of English approximant [ɹ] in the production of some Intermediate learners. Once again, given the general hypothesis that native-like mastery is possible, we predict target-like production of the Spanish tap by the Advanced group.

3.1.3 Hypotheses regarding epenthesis

Cluster-medial epenthesis should arguably pose the greatest difficulty for English-speaking learners, given its absence in their L1 and the need to master a number of conditioning variables, including liquid type and cluster voicing. As concerns clusters involving rhotics, we predict that the least proficient Intermediate speakers may fail to epenthesize, at least in voiceless environments. While syllable-initial stop+stop clusters are indeed prohibited in English, epenthesis is but one of several avoidance strategies. One logical possibility available to English-speaking learners is the substitution of an approximant for the target tap. Use of [ɹ], which would favour affrication in voiceless clusters as per their L1, makes epenthesis unnecessary. If epenthesis does occur, it should be favoured in voiced clusters for two reasons. First, it is easier to realize the tap as voiced in a voiced environment such as that of the VCV sequence resulting from epenthesis. Second, and more importantly, the perceptual cues to voicing (i.e., the longer vowel observed in the native speaker data) are more salient. In the case of the Advanced learners, we predict native-like rates of epenthesis concomitant with target-like vowel length.

3.1.4 Summary: native-like attainment and developmental sequences

To summarize the hypotheses forwarded above, we predict native-like attainment for some of the Advanced learners. The majority of learners will most likely fail to acquire at least one of the three properties in question. As concerns relative difficulty, we propose that the greater the degree of variability in the realization of a given property, the more difficult its acquisition. If true, an implicational hierarchy of difficulty can be predicated. Stop voicing in Spanish SL clusters is unambiguous, with speakers making a clear contrast between voiceless and voiced stops in terms of percent voiced. Indeed, voicing cues (i.e., presence/absence of F0; length) are reliable cues in Spanish (Colantoni & Steele 2004). As concerns the rhotic, while it is generally realized as a tap, variability does exist with fricativized and approximant variants being observed in some speakers' production (see footnote 2). The variability in rhotic manner is thus greater than that of stop voicing. Finally, SL cluster epenthesis is highly variable. As discussed, there are a variety of conditioning variables, including liquid type and stop voicing, among others. We thus predict the implicational scale in (2) below.

(2) Acquisition difficulty hierarchy in Spanish SL clusters:
Epenthesis ⊃ rhotic ⊃ stop voicing

If the above hierarchy holds, learners should master epenthesis only once the phonetic properties of the stop and rhotic have been acquired. Moreover, less advanced learners may master some properties (i.e., stop voicing, or stop voicing & rhotic manner) without mastering others.

3.2 Current study
3.2.1 Subject group

Participants were 10 English-speaking Spanish learners (5 Intermediate; 5 Advanced). The Intermediate learners had taken at least two years of university-level Spanish and were required to have spent a minimum of three months in a Spanish-speaking country. Advanced speakers, in contrast, had all lived at least one year in a Spanish-speaking milieu. Moreover, they all had graduate degrees in Spanish. Proficiency levels were verified via a reading passage administered as part of the experiment. Each learner was asked to read the text 'El viento del norte' (see Appendix 1) out loud. Following the experiment, the ten learner readings were interspersed with those of two native speakers. The twelve recordings were then randomized and presented to a native speaker judge who had no training in linguistics and was unaware of the goals of the study. Following the methodology outlined in Bongaerts et al. (2000) and Birdsong (2003), the judge was asked to rate each of the readings on a scale from 1 (heavy accent; clearly non-native) to 5 (no foreign accent; definitely native). The judge's ratings (Table 2) were consistent with the proficiency level assigned during subject recruitment. The average rating for the two groups is noticeably different (Intermediate: mean 1.8, range 1.0-2.5; Advanced: mean 3.8, range 3.0-4.5). More importantly, there was no overlap between the two groups.

Intermediate		Advanced	
Subject	*Rating*	*Subject*	*Rating*
SI01	2.5	SA01	4.0
SI06	2.0	SA02	4.0
SI07	1.5	SA07	3.5
SI08	1.0	SA08	4.5
SI09	2.0	SA09	3.0
Average	**1.8**	**Average**	**3.8**

Table 2: Judge's evaluation of subject proficiency-level based on reading passage

Table 3 presents two other characteristics of interest. As concerns age at onset of acquisition, all but one of the subjects were post-puberty learners.[7] This is important for the general hypothesis to be tested here. Indeed, claims concerning the impossibility of native-like pronunciation in non-primary language acquisition generally apply to post-puberty adult learners, not to child L2 acquisition. Second, there were considerable differences in terms of exposure to target language input between the two groups. In order to ensure that all subjects had had sufficient exposure to the target structure, one criterion for participation was having spent time in a Spanish-speaking environment. A 3-month minimum was required of Intermediate learners; Advanced learners needed at least six months. In summary, the learners constitute two different groups as concerns their L2 Spanish proficiency, average age of onset of acquisition, and total exposure to native input.

Characteristic	Intermediate *Average*	Advanced *Average*
Age at onset of acquisition	**24**	**19**
Total immersion in Spanish-speaking milieu (months)	**6**	**19**

Table 3: Learner characteristics

3.2.2 Tasks

The learners performed three tasks, including the reading passage discussed in §3.2.1, the word-reading task from Colantoni and Steele (In press) and a mirror English task. The Spanish task included

[7] Perhaps not surprisingly, the exception - learner SA08 who started acquiring Spanish at age 11 and who had the second greatest exposure to native Spanish input (3 consecutive years in Madrid) - is also the subject receiving the highest rating in the reading task.

44 targets[8] involving SL clusters, with the clusters being controlled for stop voicing, liquid type, stress and position in the word (see Appendix 2A). Thirty-five (35) distractors were intermixed with the target stimuli. Subjects were also tested on 40 parallel English stimuli involving SL clusters (Appendix 2B) in order to verify the absence of epenthesis in their L1. The English stimuli too were accompanied by distractors. In both tasks, targets and distractors were embedded in a carrier sentence ("*Digo* [TARGET] *otra vez*; " "*I say* [TARGET] *again*") and presented in written form to the subjects on note cards.

3.2.3 Methodology

Subjects were tested individually in a quiet room. The Spanish stimuli were read three times, each time in random order, generating a total of 132 SL tokens per subject. Between each round, the subjects were given an approximate five-minute break. During the first break, subjects completed a background questionnaire. Following the three rounds, learners read the text 'El viento del norte'. Finally, the English stimuli were read once. All four rounds were recorded (44100Hz; 32bit; Stereo) using a Marantz CDR300 CD recorder and unidirectional Audiotechnica AT803B lavaliere microphone.

3.2.4 Data analysis

Sound files were downsampled (22050Hz; 16-bit; mono) and tokens involving clusters were extracted and labelled. For all such tokens, stop length and voicing; liquid length and voicing;[9] and epenthesis were measured using Praat 4.0.41. As concerns epenthesis, the presence of a cluster-medial vowel was determined. When present, the vowel's length was measured. Results were exported to a spreadsheet and statistics were calculated with SAS 8.12 (significance was set at .05).

4. Results and hypothesis evaluation

4.1 English stop-liquid clusters

		# Epenthesis	# Clusters	Rate of epenthesis
Intermediate	SI01	3	40	.08
	SI06	1	40	.03
	SI07	0	40	.00
	SI08	1	40	.03
	SI09	1	40	.03
	Sum/Average	**6**	**200**	**.03**
Advanced	SA01	2	40	.05
	SA02	0	40	.00
	SA07	0	40	.00
	SA08	1	40	.03
	SA09	0	40	.00
	Sum/Average	**3**	**200**	**.02**

Table 4: Epenthesis rates: English stop-liquid clusters

[8] The Spanish SL stimuli were the same as those used in Colantoni and Steele (In press). In a follow-up experiment testing Chilean speakers, three more stimuli were added (*atlas* [atlas], *atleta* [atleta], *atlético* [atletiko]). The L2 learners were also tested on these latter stimuli.

[9] Following Colantoni and Steele (2004), voicing in both the stop and rhotic was measured in terms of percentage voiced for three reasons. First, both voiced and voiceless stops in Spanish may be voiced during the first half of the segment; this cannot be captured with VOT measurements. Second, measuring percentage voiced allows for the inclusion of instances of fully phonetically voiced realizations of phonemically voiceless stops. Third, as VOT is not a relevant measure for the rhotic, using percentage voiced allowed for comparison of voicing in stops and rhotics.

The learners' realization of the English SL clusters was consistent with expectations. As shown in Table 4, virtually no epenthesis was detected. Rhotic clusters were realized with an approximant [ɹ] almost without exception. Moreover, there was considerable affrication, especially in /tɹ/ tokens.

4.2 Spanish clusters

4.2.1 Stop voicing

With the exception of the least advanced speaker SI08 (see Table 2), participants showed a clear distinction between voiceless and voiced stops across place of articulation.

		Labial		Coronal		Dorsal	
		p	b	t	d	k	g
Intermediate	SI01	.33	.86	.06	.61	.04	.85
	SI06	.17	.76	.16	.77	.15	.67
	SI07	.17	.93	.27	.94	.44	.71
	SI08	.21	.41	.08	.28	.22	.28
	SI09	.18	.98	.20	.96	.19	.95
	Average	**.21**	**.79**	**.15**	**.71**	**.21**	**.69**
Advanced	SA01	.09	.86	.28	.90	.01	.88
	SA02	.03	.97	.25	.96	.31	.94
	SA07	.22	1.0	.45	.96	.18	.87
	SA08	.22	.94	.45	.91	.19	.94
	SA09	.49	.91	.43	.88	.40	.72
	Average	**.21**	**.94**	**.37**	**.92**	**.22**	**.87**

Table 5: Stop voicing (% voiced): Individual results

Table 6 gives the means for the Intermediate and Advanced learners as a group. The values reported for the native speaker values are those given in Colantoni and Steele (2004).

	Labial		Coronal		Dorsal	
	p	b	t	d	k	g
Intermediate	.21	.79	.15	.71	.21	.69
Advanced	.21	.94	.37	.92	.22	.87
Native Speaker	.31	.95	.30	.94	.33	.95

Table 6: Stop voicing (% voiced): Group comparisons

As a group, the Intermediate learners differ clearly from the native speakers. The Advanced group means are much more similar, being almost identical for coronal place of articulation.

While group means reveal developmental trends, one must inspect individual means to evaluate the hypotheses in question here. Indeed, for any English-speaking learner, s/he can be said to have acquired Spanish stop voicing only if there is some native speaker control from whom s/he is statistically indistinguishable. For each learner, Table 7 gives the total number of native speakers who share the same mean values (% voiced) for both voiceless and voiced stops. For example, Intermediate learner SI01 shares mean voicing values with 1 of the 10 native speakers. All of the learners resemble at least one of the controls in terms of stop voicing.

	Intermediate learners					Advanced learners				
	SI01	SI06	SI07	SI08	SI09	SA01	SA02	SA07	SA08	SA09
#Native speakers	1	1	1	1	6	2	7	8	6	6

Table 7: Stop voicing: L2 learner-native speaker pairs with no significant difference in voicing[10]

[10] Results are those of a one-way ANOVA test ($F_{(19, 2387)}$= 11.22, $p < 0.0001$) as well as a post-hoc Fisher's LSD test.

4.2.2 Rhotic

Native-like mastery of the rhotic of a Spanish stop-rhotic cluster not only requires mapping the learners' L1 allophone [ɾ] as the target language rhotic. Learners must also master the articulation of the tap, both in terms of length and voicing.

Table 8 provides mean rhotic length for each speaker across place of articulation. In native Spanish, the tap is 20ms in length on average (e.g., Quilis 1993). Both of the learner group averages exceed this. However, the Advanced group's means are shorter than those of their Intermediate counterparts. The longer stops of the Intermediate group are due for the most part to the manner in which the rhotics were realized. The most common variant was the L1-transferred approximant [ɹ] followed by apical trills and fricatives (i.e., the second half of an affricate). The presence of trills, relatively long segments, had a particular effect in increasing the mean length of the rhotic for the Intermediate learners as a group.

		Preceding stop					
		p	b	t	d	k	g
Intermediate	SI01	32	37	44	36	34	40
	SI06	25	27	27	31	26	24
	SI07	44	37	37	27	42	40
	SI08	35	35	36	38	40	34
	SI09	30	23	38	26	37	26
	Average	**33**	**32**	**36**	**32**	**36**	**33**
Advanced	SA01	23	26	22	26	29	25
	SA02	30	24	30	27	31	29
	SA07	26	27	27	29	27	28
	SA08	23	23	23	28	26	26
	SA09	43	29	30	28	38	40
	Average	**29**	**26**	**26**	**28**	**30**	**27**

Table 8: Rhotic length (ms): Individual results

Rhotic voicing proves more problematic. In native Spanish, [ɾ] is voiced throughout its articulation. In contrast, both learner groups show difficulty maintaining voicing.[11] Two exceptions are Advanced speakers SA01 and SA07, not including the latter's labial clusters. Note that there is improvement in the group means for both coronal and dorsal clusters.

		Preceding stop					
		p	b	t	d	k	g
Intermediate	SI01	.32	.36	.44	.36	.33	.41
	SI06	.65	.68	.39	.67	.72	.85
	SI07	.66	.90	.37	1.0	.49	.93
	SI08	.68	.87	.71	.85	.60	.71
	SI09	.64	.89	.57	1.0	.66	1.0
	Average	**.59**	**.74**	**.50**	**.78**	**.56**	**.78**
Advanced	SA01	.77	.78	.90	.93	1.0	1.0
	SA02	.22	.33	.84	.92	.58	.71
	SA07	1.0	1.0	.91	.97	.96	1.0
	SA08	.66	.89	.51	.83	.81	.89
	SA09	.63	.85	.53	.90	.88	.84
	Average	**.66**	**.77**	**.74**	**.91**	**.85**	**.89**

Table 9: Rhotic voicing (% voiced): Individual results

[11] Some of the problem with devoicing is related to the learners' affrication. When affricated, target <r> was generally devoiced.

Once again, in order to determine whether any of our learners has acquired the Spanish rhotic in a native-like manner, it is necessary to do individual comparisons. As was the case with stop voicing, comparison of group means for both length and voicing obscures individual success in acquisition. Table 10 shows that 5 of the speakers (2 Intermediate, 3 Advanced) did not differ significantly from at least one of the native speaker controls in terms of both the length and voicing of the tap. Two of our subjects (SA01, SA07) were highly native-like, resembling most native speakers as concerns rhotic length and voicing.

	Intermediate					Advanced				
	SI01	SI06	SI07	SI08	SI09	SA01	SA02	SA07	SA08	SA09
Length: # Native Speakers	0	9	0	1	2	8	7	8	9	0
Voicing: # Native speakers	0	0	1	1	1	9	0	9	1	1

Table 10: Rhotic overall (length & voicing): L2 learner-native speaker pairs with no significant difference in voicing ($p < .05$)[12]

4.2.3 Epenthesis

It was predicted that, given the virtually categorical asymmetry between lateral and rhotic clusters in native Spanish, neither Intermediate nor Advanced learners would epenthesize with laterals. This prediction is borne out. As shown in Table 11, virtually no epenthesis occurred in lateral clusters.

		# Epenthesis	# Clusters	Rate of epenthesis
Intermediate	SI01	4	57	.07
	SI06	0	63	.00
	SI07	0	57	.00
	SI08	1	63	.02
	SI09	0	63	.00
	Average			**.02**
Advanced	SA01	0	63	.00
	SA02	1	61	.02
	SA07	0	62	.00
	SA08	0	62	.00
	SA09	0	57	.00
	Average			**.00**

Table 11: Epenthesis rates in learners' Spanish stop-lateral clusters

In contrast, the L2 learners' rhotic clusters involved varying degrees of epenthesis (Table 12). In the case of voiceless stop-rhotic clusters, the Intermediate learner mean of 24% was much lower than that of the native speakers (94%). This is in part related to their approximant and fricative realizations of the rhotic. Colantoni and Steele (In press) argue that epenthesis is a dissimilatory process which serves to increase the articulatory and perceptual difference between the stop and rhotic. Should the rhotic change in manner via fricativization or approximantization, the drive towards dissimilation is reduced, as it is less like the preceding stop. As such, the Intermediate learners' lower rate of epenthesis is arguably related—at least in part—to their non-mastery of the Spanish tap. The lower rate of epenthesis in voiceless clusters is also consistent with the proposal outlined in §3.1.3 that approximant variants are more likely in voiceless environments which favour affrication. Note that there are two Intermediate learners (SI01, SI06) for whom there is considerable epenthesis in such clusters. The Advanced group mean, in contrast, is much closer to that of the native speaker controls. Moreover, learners SA07 (100%) and SA08 (97%) resemble their native speaker counterparts.

[12] One-way ANOVA; Length: $F_{(19, 1340)}= 17.97$; $p < 0.0001$; Voicing: $F_{(19, 1340)}= 20.45$; $p < 0.0001$. The results presented here correspond to the Fisher's LSD post-hoc test.

		# Epenthesis	# Clusters	Rate of epenthesis
Intermediate	SI01	13	32	.41
	SI06	21	33	.64
	SI07	2	32	.06
	SI08	1	33	.03
	SI09	2	33	.06
	Average			**.24**
Advanced	SA01	28	33	.85
	SA02	15	33	.45
	SA07	33	33	1.00
	SA08	32	33	.97
	SA09	24	32	.75
	Average			**.80**

Table 12: Epenthesis rates in learners' Spanish voiceless stop-rhotic clusters

Both groups were more successful in mastering epenthesis in voiced clusters as a whole (Table 13). While the Intermediate group's mean rate of 79% falls short of that of the native speaker controls (97%), it is triple that of their mean for voiceless clusters. Moreover, there is one learner (SI01) whose rates are native-like. The Advanced group mean of 97% is identical to that of the controls.

		# Epenthesis	# Clusters	Rate of epenthesis
Intermediate	SI01	32	33	.97
	SI06	30	36	.83
	SI07	30	35	.86
	SI08	17	36	.47
	SI09	28	35	.80
	Average			**.79**
Advanced	SA01	36	36	1.0
	SA02	33	36	.92
	SA07	34	36	.94
	SA08	36	36	1.0
	SA09	35	35	1.0
	Average			**.97**

Table 13: Epenthesis rates in learners' Spanish voiced stop-rhotic clusters

In contrast, as shown in Table 14, the length of the epenthetic vowel was often non-target-like. Recall that the mean length of the epenthetic vowel was 31-40ms for the Argentinean native speakers. With the exception of the Advanced group's voiced clusters, mean lengths were too short.

		Voiceless	Voiced
Intermediate	SI01	17	33
	SI06	18	24
	SI07	20	30
	SI08	17	17
	SI09	18	27
	Average	**18**	**26.2**
Advanced	SA01	23	27
	SA02	17	27
	SA07	31	47
	SA08	22	30
	SA09	20	20
	Average	**22.6**	**30.2**

Table 14: Vowel length (ms) in learners' epenthetic forms

This is not to say that some learners did not master vowel length. Speaker SA07 has target-like values for both voiceless and voiced clusters. Speakers SI01, SI07, SI09, SA01, SA02, and SA08 fall within the range of values observed in the Argentinean speaker data for voiced clusters. Returning to group means once again, learners did have longer vowels in voiced environments, as was the case with the control data.

4.2.4 Summary of results and hypothesis evaluation

As predicted, stop voicing was the most readily acquired of the three phonetic properties by both the Intermediate and Advanced speakers. All speakers had at least one native control with whom there was no statistical difference in the mean percentage voiced for both voiceless and voiced stops. Learners were less successful in acquiring native-like mastery of the Spanish rhotic. On average, the rhotic was too long and only partially voiced. This is in part due to L1 transfer of approximant [ɹ]. Such substitution was most common with Intermediate speakers, particularly learner SI08. Contrary to our hypotheses, not all Advanced learners mastered the target rhotic, particularly as concerns voicing. Finally, epenthesis did indeed prove to be the most difficult phonetic property to master, as predicted. While the lateral-rhotic asymmetry was mastered,[13] the overall rate of epenthesis was too low in voiceless rhotic clusters with two exceptions. The hypothesis that some Intermediate speakers would fail to epenthesize was only partially borne out. Whereas epenthesis was virtually absent from the production of subjects SI07, SI08 and SI09, this was not the case in voiced clusters. Indeed, learners were significantly more accurate with epenthesis in voiced environments: seven of the ten speakers had mastered this property. Finally, on average, the epenthetic vowel was too short.

While the analysis to this point allows for evaluation of the specific hypotheses, as stated earlier, native-like attainment of Spanish stop-liquid clusters requires mastery of all three properties by the same learner. In the next section, we will evaluate our general hypotheses and determine whether any of the English-speaking learners tested managed to do so.

4.3 Ultimate attainment

Table 15 below offers a speaker-by-speaker comparison of overall success in acquiring the three phonetic properties (S: stop voicing; R: rhotic length and voicing; E: epenthesis rate and vowel length) necessary for mastery of the Spanish SL clusters.

	SC01			SC02			SC03			SC04			SC05			SC06			SC07			SC08			SC09			SC10		
	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E
SI01																■														
SI06																■														
SI07																■														
SI08																■														
SI09							■			■			■			■						■			■					
SA01		■									■		■			■	■			■			■			■			■	
SA02	■						■			■						■						■			■			■		
SA07	■	■	■		■	■	■	■		■			■			■	■	■			■	■	■	■	■		■	■	■	■
SA08									■	■			■	■		■						■			■		■	■		
SA09	■			■			■						■	■		■						■			■			■		

Table 15: L2 learner-native speaker comparisons: individual mean values for stop voicing, rhotic length & voicing, and epenthesis rate & vowel length

[13] While we have spoken of the learners' mastery of the lateral-rhotic asymmetry, we have taken for granted that the absence of epenthesis in stop-lateral clusters has been 'acquired'. Clearly, this may be the result of transfer. If learners have truly acquired Spanish stop-lateral clusters, there may be measurable differences vis-à-vis English. These include place of articulation (dental in Spanish versus alveolar in English) and, potentially, length. Lacking such measurements here, we must leave this for future research.

Each of the English-speaking learners in the leftmost column is compared with each of the native speaker controls (SC01-10) as concerns the three phonetic properties under investigation. A black square indicates no statistical difference ($p<.05$) between the learner and the native control for the given parameter. For example, learner SI01's stop voicing is indistinguishable from that of control SC06. Accordingly, for a learner to be truly native-like, their values for stop voicing, rhotic length and voicing, and epenthesis rate and vowel length must be statistically indistinguishable from a single native speaker. There is no Intermediate learner for whom this is the case. However, one Advanced speaker, SA07, shares mean values for all three properties with four of the controls (SC01, SC06, SC08, SC10). This learner alone, who began acquiring Spanish at age 24, can be said to have native-like pronunciation of SL clusters.

A number of other generalizations can be made. First, not surprisingly, the Advanced learners were much more successful in acquiring the phonetic properties of Spanish SL clusters on the whole. Whereas those Intermediate speakers who matched with some native speaker control did so only for voicing, 4 of the 5 Advanced learners were statistically indistinguishable from at least one of the native speakers for two of the three properties. Second, mastery of the rhotic and epenthesis are good measures of proficiency. Whereas neither property was acquired natively by any of the Intermediate speakers, 4 of the 5 Advanced speakers paired with some control for the rhotic; 2 Advanced speakers mastered epenthesis.

5. Conclusions

While most learners – both Intermediate and Advanced – failed to master the target SL clusters, the performance of one of ten learners was indistinguishable from the native speaker controls. Moreover, this learner had begun to acquire Spanish at age 24. While this is consistent with the possibility of native-like attainment in L2 acquisition as argued for in Bongaerts et al. (2000) and Birdsong (2003), it demonstrates that such mastery is exceptional. For the most part, learners failed to master at least one – and often all – of the phonetic properties necessary for target-like realization of Spanish SL clusters. It is interesting that subject SA07, the most successful speaker in terms of the phonetic parameters measured here, was not the speaker given the highest rating on the reading passage. Whereas SA07 scored 3.5 out of 5, three of the four other Advanced speakers received higher ratings, including a rating of 4.5 for subject SA08. Clearly, other aspects of speaker SA07's L2 Spanish, for example, segmental properties such as vowel quality and prosodic qualities including intonation and speech rate, must be less native-like. Subject SA08, the most native-like speaker based on the judge's global evaluation, mastered all three properties but only as compared to several different native speaker controls. One possibility is that, beyond the individual variation highlighted here, there may be cross-dialectal differences in one or all of the parameters. For instance, Rosner et al. (2000) show that Castilian and Latin American varieties differ significantly in VOT values, in particular for voiced stops. Similar variation may exist as concerns rhotic manner and epenthesis. Were learner SA08's production compared with that of speakers of peninsular Spanish, the target variety to which she was exposed during three years of immersion, the comparison might be more favourable. A serious problem with such a hypothesis is that peninsular Spanish was also the primary input of learner SA07, the most successful learner in terms of the properties measured here. However, it is nonetheless generally true that, whereas native speakers normally have a single target variety, in the case of L2 acquisition, the target and input may vary. Such variation represents a challenge for learners.

Our hypothesis concerning a hierarchy of acquisition difficulty also received support from the experimental data. On the assumption that variability in the realization of a given phonetic property represents greater difficulty for the learner, we predicted the developmental sequence of stop voicing before rhotic manner before epenthesis; this prediction was borne out. If input variability is the relevant factor, it is not surprising that mastering epenthesis proves so difficult, as the conditioning variables are varied and there is interspeaker variation in native Spanish. Variation does not, however, explain the difficulties encountered with the target rhotic in any great likelihood. Indeed, the difference between English [ɹ] and Spanish [ɾ] is perceptually very salient. Moreover, the learners already were familiar with the tap as an L1 allophone. We propose that two factors are at play. First, as concerns length, English [ɾ] is considerably longer than its Spanish counterpart. The flaps in the English tokens

'gritty' and 'fruity' elicited in the English stimuli were on average 40ms in length. An English learner who classifies the English and Spanish flaps as equivalent may fail to make the adjustments necessary in length. Second, as concerns voicing, learners must learn to control length, that is, the very short closure necessary for the tap. As such, the findings here suggest that a complete explanation of learners' failure to master target phonetic properties must look both at perception (i.e., input and cues) and production (i.e., articulatory constraints).

In conclusion, the English-Spanish SL data examined here provide evidence of the possibility of native-like attainment with one of the ten learners. However, such attainment is clearly exceptional. If post-puberty learners can acquire target-like pronunciation, non-native pronunciation observed in most learners cannot be due to maturation alone. Whereas previous claims concerning the difficulty or impossibility of native-like attainment have focussed on maturational constraints such as the development of language-specific speech perception and neurological changes including lateralization, we have argued here that input variability is an important factor meriting further investigation. Indeed, learners' difficulty in parsing variability may inhibit accurate learning. The more categorical a phonetic property, the more likely it will be mastered, at least by some learners.

Appendix 1: Text for evaluating learner subject level

El viento del norte y el sol discutían acerca de cuál de los dos sería el más fuerte, cuando, de repente, pasó un viajero envuelto en una amplia capa. Al verlo, convinieron en que el primero que consiguiera quitarle la capa sería el más fuerte. El viento del norte comenzó a soplar con mucha furia, pero, cuanto más soplaba, más se aferraba el viajante a su capa, hasta que el viento norte desistió. El sol brilló entonces con todo su esplendor, e inmediatamente, el viajante arrojó su capa. Así, el viento norte tuvo que reconocer la superioridad del sol.

Appendix 2: English and Spanish stimuli

Word shape	Liq	Labial		Coronal		Dorsal	
		p	b	t	d	k	g
CLV	[l]	*plan* [plan]	*bla* [bla]	*	*	*clan* [klan]	*
	[ɾ]	*	*	*tras* [tras]	*	*	*gran* [gran]
CLV. 'CV	[l]	*plegó* [pleɣo]	*blasón* [blason]	*	*	*clavé* [klaβe]	*
	[ɾ]	*prevé* [preβe]	*bramó* [bramo]	*traté* [trate]	*drogó* [droɣo]	*creyó* [kreʒo]	*grabé* [graβe]
CV. 'CLV	[l]	*soplé* [sople]	*doblá* [doβla]	*	*	*	*
	[ɾ]	*	*cobrá* [koβra]	*	*podré* [poðre]	*lucrá* [lukra]	*lográ* [loɣra]
'CV.CLV	[l]	*sopla* [sopla]	*tabla* [taβla]	*	*	*tecla* [tekla]	*regla* [reɣla]
	[ɾ]	*lepra* [lepra]	*sobra* [soβra]	*letra* [letra]	*sidra* [siðra]	*sacra* [sakra]	*negra* [neɣra]
'CLV.CV	[l]	*plato* [plato]	*bledo* [bleðo]	*	*	*claro* [klaro]	*globo* [gloβo]
	[ɾ]	*prado* [praðo]	*brazo* [braso]	*traje* [traxe]	*drama* [drama]	*crema* [krema]	*grave* [graβe]

Appendix 2A: Spanish stimuli

Word shape	Liq	Labial		Coronal		Dorsal	
		p	b	t	d	k	g
CLV	[l]	*play* [ple]	*blow* [blo]	*	*	*clay* [kle]	*glue* [glu]
	[ɹ]	*pray* [pɹe]	*bra* [bɹɑ]	*tray* [tɹe]	*draw* [dɹɑ]	*crow* [kɹo]	*grey* [gɹe]
CLV.CV	[l]	*plushy* [plʌʃi]	*bloody* [blʌdi]	*	*	*cloudy* [klɑwdi]	*glassy* [glæsi]
	[ɹ]	*pricey* [pɹajsi]	*breezy* [bɹizi]	*trophy* [tɹofi]	*droopy* [dɹupi]	*crazy* [kɹezi]	*gritty* [gɹɪɾij]
CV.CLV	[l]	*supply* [sʌplaj]	*doubly* [dʌbli]	*	*	*likely* [lajkli]	*vaguely* [vegli]
	[ɹ]	*repro* [ɹipɹo]	*cobra* [kobɹɑ]	*betray* [bətɹe]	*hydro* [hajdɹo]	*micro* [majkɹo]	*degree* [dəgɹi]
CV.CLV.CV	[l]	*diploma* [dəplomə]	*publisher* [pʌblɪʃəɹ]	*	*	*recliner* [ɹəklajnəɹ]	*neglecting* [nəglɛktɪŋ]
	[ɹ]	*soprano* [səpɹæno]	*library* [lajbɹəɹi]	*petrify* [pɛtɹɪfaj]	*addresses* [ædɹəsəz]	*secrecy* [sikɹəsi]	*engraver* [əngɹevəɹ]

Appendix 2B: English stimuli

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