J. Child Lang. **45** (2018), 788–806. © Cambridge University Press 2017
doi:10.1017/S0305000917000460

BRIEF RESEARCH REPORT

Development of Spanish rhotics in Spanish–English bilingual children in the United States*

Mandy R. MENKE
University of Minnesota, USA

(*Received* 24 *May* 2016 – *Revised* 6 *February* 2017 – *Accepted* 18 *September* 2017 – *First published online 17 November 2017*)

ABSTRACT

Rhotics, particularly the trill, are late acquired sounds in Spanish. Reports of Spanish–English bilingual preschoolers document age-appropriate articulations, but studies do not explore productions once exposure to English increases. This paper reports on the rhotic productions of a cross-sectional sample of 31 Spanish–English bilingual children, ages 6;8 to 13;5. Children produced taps with high rates of accuracy across age groups; the trill did not reach 80% target production until age 11;3, later than reported for monolingual speakers. Increased English exposure is explored as a contributing factor, arguing a need for continued study of bilingual phonological development beyond the preschool years.

Introduction

The rhotics are among the most difficult sounds for Spanish-speaking children to acquire; while the tap, [ɾ], is acquired around the age of four years (Acevedo, 1993; Bosch Galcerán, 1983; Melgar de González, 1976), the trill, [r], is acquired later, after the age of five (Acevedo, 1993) or six (Bosch Galcerán, 1983; Linares, 1981; Melgar de González, 1976).[1] Some work with Spanish–English bilinguals has documented slightly later ages of acquisition than monolingual speakers (e.g., Fabiano-Smith & Goldstein, 2010), but Goldstein, Fabiano, and Washington (2005)

* This work was supported by a Thesis Research Grant from the Graduate School at the University of Minnesota. The project would not have been possible, however, without the cooperation of the students, teachers, and parents at the participating school. In addition, Lindsey Dietz was pivotal in creating a statistical model that allowed for meaningful comparisons to be made. Address for correspondence: Department of Spanish & Portuguese Studies, 214 Folwell Hall, 9 Pleasant St SE, Minneapolis MN 55455, USA. e-mail: menkem@umn.edu

[1] For the studies cited, the threshold for acquisition was set at 90%.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

conclude that there are fewer differences as children grow older. Studies have not followed these children beyond the onset of schooling to explore how increased exposure to English impacts their articulations. This study sets out to describe the rhotic productions of school-aged, Spanish–English bilingual children and how they differ according to age; findings will both inform our understanding of child bilingual language development as well as our descriptions of the speech of Spanish–English bilingual speakers in the southwest United States. The specific research questions that guided this project are:

1. How do Spanish–English bilingual children produce taps and trills? Do they differentiate between the two phonemic contexts? If so, how?
2. How do children's productions differ according to age?

Previous Work

Spanish tap and trill. Spanish has two rhotic phonemes, a tap /ɾ/ and a trill /r/. Although the phonemic distinction exists only in word-medial, intervocalic position (1a), the trill is categorically produced in word-initial position (1b) and the tap in onset clusters, following a tautosyllabic consonant (1c). In all other contexts, the two phones are in free variation.

(1a)	phonemic contrast	V__V intervocalic
	tap /ɾ/ versus trill /r/	/ˈse.ɾo/ *cero* 'zero' versus /ˈse.ro/ *cerro* 'hill'
(1b)	trill [r] only	word-initial
		/re.ˈlox/ *reloj* 'clock, watch'
		C.__ following a heterosyllabic consonant
		/en.ri.ˈke.se/ *enriquece* 'he/she/it enriches'
(1c)	tap [ɾ] only	C__ in onset cluster, following a tautosyllabic consonant
		/ˈbɾa.so/ *brazo* 'arm', /ˈpɾis.ma/ *prisma* 'prism'

Phonetic realizations of the two sounds vary across speakers, contexts, and dialects. Although phonetic manifestations of taps vary in the degree of constriction or closure, ranging from complete closure to vowel-like approximants (Blecua Falgueras, 2001), greater variation is evidenced for trills. Traditional definitions describe the trill as having two or more brief occlusions (e.g., Quilis, 1993); nonetheless, the number of occlusions as well as the nature of the closure phases have been shown to vary. In addition, other manners of articulation have been reported for the trill, among them assibilated trills, uvular trills, approximants, taps, and pre-aspirated or pre-breathy taps (e.g., Blecua Falgueras, 2001; Bradley & Willis, 2012; Colantoni, 2001; Henrikson & Willis, 2010; Lipski, 1994; Willis & Bradley, 2008). In light of variation in manner of articulation,

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Willis and Bradley (2008) and Henrikson and Willis (2010) suggest that segment duration may be the acoustic cue that best distinguishes the two phonemes; trills are consistently longer in duration than taps (Blecua Falgueras, 2001; Henrikson & Willis, 2010; Willis & Bradley, 2008). In order to distinguish expected productions from actual productions in the remainder of the paper, the terms 'phonemic' and 'phonetic' will be used. Phonemic trill and phonemic tap refer to the expected production based on the linguistic context (1a–1c), whereas phonetic trill and phonetic tap refer to actual productions or phonetic realizations.

First language (L1) acquisition of Spanish rhotics. Findings from work with typically developing, monolingual, Spanish-speaking children point to acquisition of most sounds by the age of 5;0 (e.g., Maez, 1981); rhotics, however, are among the few sounds not acquired by this age (Acevedo, 1993; Melgar de González, 1976; Mason, Smith, & Hinshaw, 1976). While most studies point to acquisition of the tap by the age of 4;0 or 4;6 (Bosch Galcerán, 1983; Linares, 1981; Melgar de González, 1976), no study places acquisition of the trill prior to the age of 5;0. Bosch Galcerán (1983) reported 80% accuracy in trill production at age 6;0 and 90% at age 7;0 for monolingual Spanish speakers in Spain. Similar findings have been reported for Spanish monolinguals in the United States (Acevedo, 1993; Jimenez, 1987; Linares, 1981). Little detail is available on the variability in productions as children acquire the trill; only Bosch Galcerán (1983) and Carballo (1995) have noted developmental substitutions, which include omission, simplification to a tap, and lateralization. Carballo and Mendoza (2000) concluded that accuracy in trill production is not just an effect of age; rather, it is associated with the degree of motor control.

Bilingual phonological acquisition. Different patterns of errors and rates of acquisition have been reported for bilingual phonological acquisition as a result of interaction between the two phonological systems (e.g., Dodd, So, & Li, 1996; Gildersleeve-Neumann & Davis, 1998; Goldstein & Washington, 2001). In some cases, bilingualism results in acceleration of development (e.g., Kehoe, Trujillo, & Lleó, 2001; Lleó, Kuchenbrandt, Kehoe, & Trujillo, 2003), and in others, deceleration (e.g., Gildersleeve-Neumann, Kester, Davis, & Peña, 2008; Goldstein & Washington, 2001), depending on a variety of factors including the overlap between the two phonetic systems and the amount of exposure to each language.

With respect to acquisition of Spanish rhotics, Fabiano-Smith and Goldstein (2010) find that Spanish–English bilingual preschoolers, age 3:0–4:0, are within the range of typical development despite lower

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

accuracy rates (tap: 25% vs. 33% accuracy, trill: 4% vs. 37.5% accuracy). Accuracy of rhotic articulations continues to develop in the preschool and early elementary years (Gildersleeve-Neumann, Peña, Davis, & Kester, 2009; Goldstein *et al.*, 2005) such that as age increases, differences between bilinguals and monolinguals decrease (Goldstein *et al.*, 2005). The impact of increasing English proficiency on rhotic production has not been explored, however. Baker and Trofimovich (2005) argue that cross-linguistic effects of the L2 on the L1 occur at advanced stages of L2 learning. As such, the scope of research on child bilingual phonological development must extend beyond the initial stages of L2 exposure during preschool or early elementary years. The present study examines the impact of English proficiency on the rhotic productions of a cross-sectional sample of school-aged Spanish–English bilinguals and thus expands our understanding of L1–L2 interactions in bilingual phonological development.

Methodology

Participants. A cross-sectional sample of 31 Spanish–English bilinguals living in San Antonio, Texas participated in this study. Participants were all Spanish-dominant or Spanish monolingual prior to entry into a 90:10 Spanish–English language immersion program in kindergarten. Because participants were recruited in a school setting, grade level was used as the grouping variable; biological age was relatively consistent within a grade level group, as shown in Table 1.

All grade 1, 3, 5, and 7 students in the program were invited to participate, as these grade levels represent differing amounts of content instruction in English and coincide with other studies of language use patterns (Fortune, 2001; Potowski, 2004) and phonological development (Harada, 1999; Snow & Campbell, 1985) in language immersion programs. Data were collected from those students consenting to participation. Parents completed a language background questionnaire that detailed the participant's as well as the parents' linguistic histories, and the child's language use practices outside of school. Spanish was the first language of all participants as well as the primary language of the home, used 60–80% of the time at a minimum, and both parents spoke Spanish, with at least one a native speaker. No language concerns were reported by parents or teachers for any participant. An overview of participant characteristics is presented in Table 1.

Participants were enrolled in a Spanish–English two-way (bilingual) language immersion program in a large, urban school district. Two-way immersion programs bring together majority language speakers and minority language speakers in a linguistically rich, academically challenging setting. In this program, 90% of content area instruction occurs in Spanish in Kindergarten and Grade 1; the remaining 10% is in

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table 1

Participant characteristics by grade level

	Grade 1	Grade 3	Grade 5	Grade 7
Total no.	10	9	7	6
Males	3	1	4	5
Females	7	8	4	1
Average age	7;1	9;1	11;3	12;11
Age range	6;8–7;6	8;7–9;6	11;0–11;7	12;8–13;5

English. The amount of subject matter instruction in Spanish decreases each year, so that by Grade 5 subject-matter instruction is distributed equally across the two languages. Language allocation by grade level is detailed in Table 2.

Data elicitation. Participants met with the researcher in pairs during the school day in a quiet space. After a short warm-up conversation, they completed a picture-sorting task in which they looked through 30 pictures to name the animals that answered questions such as *¿Qué animales pueden vivir en el agua?* 'Which animals can live in the water?' or *¿Qué animales comen a otros animales?* 'Which animals eat other animals?' All sessions were audio-recorded using a Marantz digital voice recorder.

Data analysis. All student speech was transcribed, and all expected tap and trill productions were identified and analyzed. Tokens were limited to the word-internal intervocalic context (1a) or word-initial context (1b).[2] Syllable stress was not controlled for, as previous studies have not reported a significant relationship between lexical stress and trill production (e.g., Blecua Falgueras, 2001; Willis, 2007); tokens of 'r' that would be produced as a flap in English, e.g., *canguro* 'kangaroo' /kan.ˈgu.ɾo/ were not included in the analysis.[3] Tokens are listed in Table A in the 'Appendix'.

Acoustic analyses were carried out in Praat v.5.4 (Boersma & Weenink, 2015). Temporal measurements and manner of articulation classification were conducted via examination of both the waveform and spectrogram image. Total consonant duration was measured in milliseconds from the

[2] The trill context was extended to the word-initial context because only one token, *perro* 'dog', was available in the word-internal, intervocalic context.

[3] In order to ensure that this was the case, additional statistical models were fit that included stress. There were no significant main effect for stress for either response time ($p = .58$) or target-like productions ($p = .31$); similarly, no interactions with stress reached significance, so it was removed from the model.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table 2

Instructional language distribution by grade

	Language distribution by grade		
	Spanish	English	Estimated cumulative English instructional time (hours)
Kindergarten	90%*	10%	126
1st grade	90%	10%	252
2nd grade	80%	20%	504
3rd grade	80%	20%	756
4th grade	70%	30%	1,134
5th grade	60%.	40%	1,764
6th grade	50%	50%	2,394
7th grade	History Spanish Language Arts	Math English/ Reading	2,604

Note. * It is common for school districts to report the amount of instructional time in each language as a percentage. From these percentages, estimates of English instructional time were made based on 7 hours of instruction each day for 180 days.

end of the preceding segment, marked by the beginning of closure duration, to the onset of the transition into the following vowel. All productions were additionally classified by manner of articulation following the categories set forth by Willis and Bradley (2008), Bradley and Willis (2012), and Rose (2010), described briefly here:

Tap: a single occlusion evidenced by the absence of energy in the waveform and a white stripe in the spectrogram;
Perceptual tap: perceptible to the ear, lacks reliable acoustic measurements, slight reduction in the amplitude of the waveform or formant intensity;
Continuant tap: no perceptible closure, formants continue throughout the duration of the segment, steady dip in the third and fourth formants;
Trill: at least two periods of closure indicated by periods of no energy in the waveform and white strips in the spectrogram;
Alveolar approximant: continuant in nature, low third formant, r-colored sound;
Tap+: single closure followed by frication or an approximant;
Assibilated variant: frication at a lower frequency in the spectrogram than sibilants
Elided: no phonetic trace;
Other: production that does not fit into other categories.

Statistical modeling necessitated binary classification of productions given the few number of productions in some manner of articulation categories. Therefore, each production was additionally labeled as either meeting a

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table 3

Tokens produced by grade level

	Grade 1	Grade 3	Grade 5	Grade 7	Total
No. of participants	10	9	7	6	31
Tap	134	110	101	63	408
Trill	44	42	42	25	153
Total	178	152	143	88	561

target or not, based upon whether productions were attested in reports of adult, monolingual speaker articulations. Taps, perceptual taps, and continuant taps were classified as meeting the target for the phonemic tap, and trills, tap+, and assibilated productions met the target for phonemic trills.

Two statistical models were developed, one for manner of articulation and another for duration. A mixed logit model (Generalized Linear Mixed Models for binomially distributed outcomes) was run in the R Statistical Package, with grade and phonemic context (expected tap or trill) as fixed effects, and a random intercept by participant, to statistically compare the phonetic realizations across phonemic contexts and grade levels. Duration data were submitted to a linear mixed-effects model with phonemic context, grade, and the interaction of phonemic context and grade as fixed effects, and a random intercept for each speaker. Because all duration data were positive, duration values were log transformed on a natural log scale prior to running the model. The predictive output of the log-transformed values was then back transformed to the normal scale to make results more interpretable.

Results

A total of 561 tokens were analyzed as part of this study. In line with frequency distributions for Spanish (Guirao & García Jurado, 1990), participants produced many more tokens of phonemic taps than trills. The number of tokens produced by participants of each grade level is broken down by phonemic context in Table 3. Results are reported first for manner of articulation and then for duration.

Manner of articulation. Productions for each grade level group are presented visually in Figures 1 and 2, with numeric details available in Tables B–E in the 'Appendix'. Phonemic taps are most frequently realized as phonetic taps across all grade levels. There is not a consistent upward trend in frequency across grades, rather there is a decrease between first and third grade, followed by an increase in fifth and seventh grade. The

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

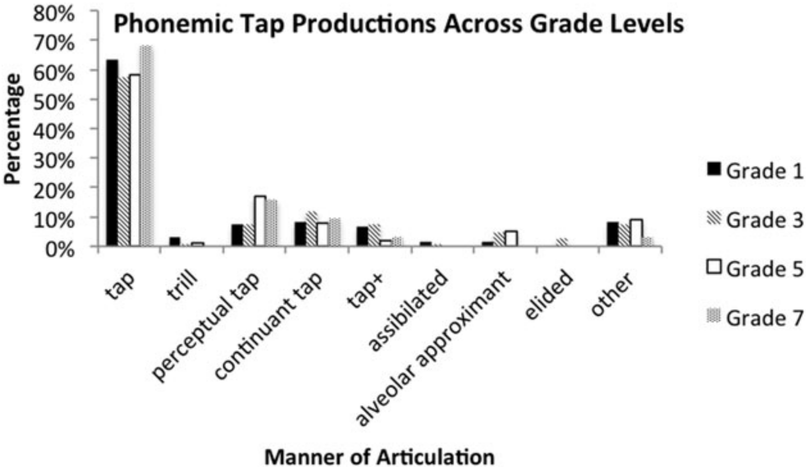

Fig. 1. Phonemic tap productions across grade levels.

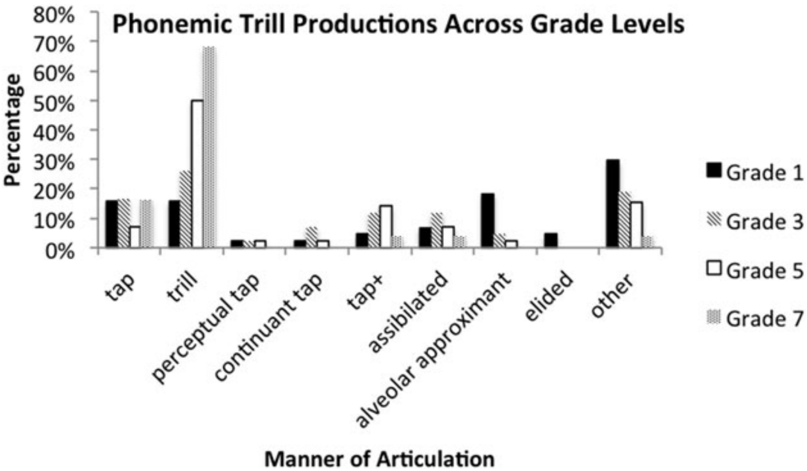

Fig. 2. Phonemic trill productions across grade levels.

perceptual tap shows a different trend in that its frequency is relatively low, approximately 7%, in the primary grades but is higher, approximately 16%, in the upper grades. Realizations of the phonemic tap as a continuant are relatively consistent at around 10%. Tap+ articulations decrease across grade levels as do 'other' productions. Finally, alveolar approximants in the phonemic tap context increase from Grade 1 to Grade 5 and then are absent among the productions of Grade 7 speakers. The most common

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table 4

Results of statistical modeling, Analysis of Deviance Table (Type II Wald chisquare tests)
Response: Target == 'Hit'

	χ^2	df	p-value
Grade	13.736	3	.003287*
phonemic context	25.041	1	<.001*
grade:phonemic context	10.21	3	.01686*

Note. * significant at the $p = .05$ level.

'other' productions were pre-breathy taps and combination segments, in which two manners of articulation are observed in the spectrogram.

Phonemic trill productions are depicted according to manner of articulation and grade level in Figure 2. Phonetic trill production is relatively low in Grade 1 at 16%, but increases steadily across grade levels to just under 70% in Grade 7; the greatest increase occurs between Grades 3 and 5, 23.8%. Across grade levels the relative proportion of 'other' and alveolar approximant productions decreases. Nearly 30% of all productions by Grade 1 participants did not fit into one of the predetermined categories; by grade 7, only 4% of productions (1 token) could not be classified. Some of these productions, such as pre-breathy taps and trills are dialectal rhotic variants, whereas others are combination segments, comprised of two distinct sounds, such as alveolar approximants followed by frication. In a similar way, production of alveolar approximants decreases from 18% in Grade 1 to 0% in Grade 7. Across grade levels, the number of closures in phonetic trills is relatively consistent: 2.7 in Grade 1, 2.5 in Grade 3, 3 in Grade 5, and 2.59 in Grade 7.

Comparing productions across the two phonemic contexts reveals that the relative percentage of phonetic taps is less in the phonemic trill context than the phonemic tap context; similarly, the relative frequency of phonetic trills in the phonemic tap context is less than that in the phonemic tap context. In addition, 'other' productions are produced with greater relative frequency in the phonemic trill context.

A mixed logit model tested the probability of target production according to the two fixed effects of phonemic context and grade, as well as their interaction. Results are displayed in Table 4. Both fixed effects as well as their interaction are statistically significant.

The interaction of grade and phonemic context is statistically significant; in other words, there is evidence that the effect of grade on rhotic production is not independent of phonemic context and vice versa. As

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

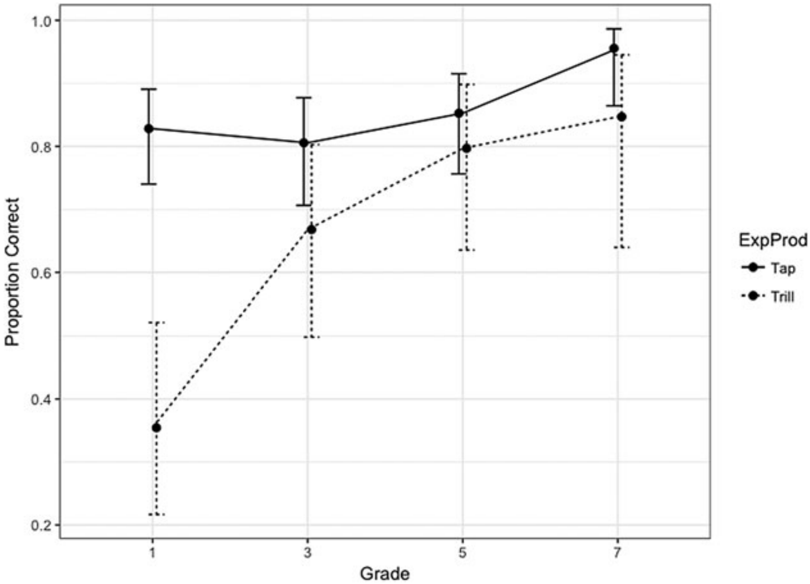

Fig. 3. Target productions of phonemic taps and trills across grade levels.

seen in Figure 3, target production of both phonemes is high in Grade 7, whereas in Grade 1, target production is only high for phonemic taps.

The main effect of phonemic context reaches statistical significance ($\chi^2(1) = 25.041$, $p < .0001$), confirming the difference observed visually in Figure 3. Target production of phonemic taps consistently exceeds that of phonemic trills. In the primary grades, participants produce the phonetic targets of phonemic taps in more than 80% of the tokens, whereas target production of phonemic trills is only 35% in Grade 1 and 67% in Grade 3. Grade 1 and Grade 3 participants are not, however, consistently substituting a phonetic tap in the phonemic trill context, as evidenced by the greater relative frequency of phonetic trills and 'other' productions in this context. A greater percentage of target productions of phonemic taps are similarly produced in the upper grades despite the increase in target productions of phonemic trills to 80% in Grade 5 and 85% in Grade 7.

The main effect of grade is also significant ($\chi^2(3) = 13.736$, $p = .003$). As seen in Figure 3, target productions increase as grade level increases, with the exception of target phonemic tap productions from Grade 1 to Grade 3, which show a slight decrease from 83% to 81%. At Grade 7, 96% of all phonemic taps productions hit the target. Phonemic trill productions evidence a greater increase in target productions, from 35% in Grade 1 to 85% in Grade 7.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Duration. Duration data are depicted visually in Figure 4 and reported numerically in Tables B–E in the 'Appendix'. Duration of phonemic trills exceeds that of phonemic taps across all grade levels. Results of statistical analyses show that there is a significant interaction between grade and phonemic context ($\chi^2(3) = 13.8669$, $p = .0023$); the difference between the two phonemic contexts increases as grade level increases. As seen in Figure 4, phonemic trill productions are approximately 30 ms longer than phonemic tap productions in Grades 1 and 3, and 55 ms longer in Grade 7. The increase in difference results from different trends in which phonemic taps decrease in duration and phonemic trills increase. The main effects of phonemic context ($\chi^2(1) = 198.8909$, $p < .0001$) and grade ($\chi^2(3) = 7.8714$, $p = .048745$) are additionally significant.

Summary of results. The first research question addresses how Spanish–English bilingual children in a two-way Spanish–English immersion program produce Spanish rhotics. Across all grade levels, the children distinguish the two phonemes via manner of articulation and total consonant duration. Although children do not produce target articulations of phonemic trills in the early grades, manner of articulation does differ across the two phonemic contexts, with fewer phonetic taps and more phonetic trills and 'other' productions in the phonemic trill context. In addition, phonemic trills are consistently longer in duration than phonemic taps. Differences in rhotic production according to age is addressed in this cross-sectional study via grade-level groups. The main effect of grade is statistically significant in both the manner of articulation and duration models, with more target productions of both phones produced in the upper grade levels than in the primary grades. Additional differences across grade levels are related to consonant duration; duration of phonemic taps decreases across grade levels, and duration of phonemic trills increases. The significance of these findings and their connection to previous studies is discussed in the following section.

Discussion

The Spanish–English bilingual children who participated in this study distinguish phonemic taps and trills by manner of articulation and consonant duration; there are also significant differences across grade level groups that show development toward an adult target. Nonetheless, noteworthy differences exist between the productions of this particular group of learners and those reported previously for monolingual Spanish-speaking children.

Previous accounts of rhotic acquisition report accuracy rates of 80% or higher for phonemic taps by age 4;0 or 4;6 (Bosch Galcerán, 1983; Linares, 1981; Melgar de González, 1976) and phonemic trills by age 7;0

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

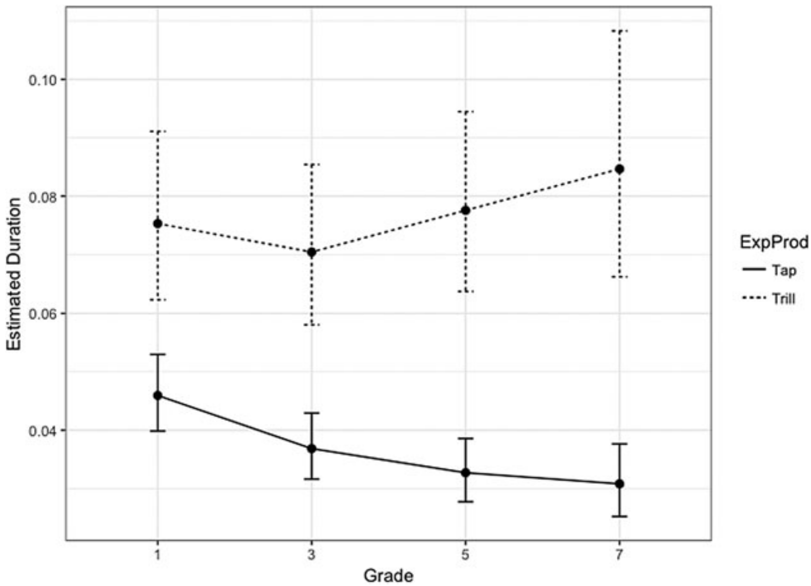

Fig. 4. Consonant duration across grade levels.

(Jimenez, 1987). The bilingual child participants in this study meet the 80% threshold by Grade 1 (age 7;1) for the phonemic tap, but it is not until Grade 5 (age 11;0) that the 80% mark is reached for the phonemic trill, a later age than previously reported. These findings, as well as the observed variability in productions, do not align with the conclusion of Fabiano-Smith and Goldstein (2010) that bilingual development falls within the range of typical development. Greater exposure to English by the present study's participants as well as the use of acoustic, as opposed to impressionistic, analysis may explain the divergent findings of this study.

Previous work assumes that once a sound is acquired it is consistently produced; in other words, once a child learns to produce the tap and trill, s/he will continue to do so. The rhotic productions of Spanish–English bilingual children in the United States have not been described after the preschool years, the point at which exposure to English typically increases as a result of schooling. Work on other sound classes and in other languages has documented an effect of L2 learning on the acoustic characteristics of L1 phones, for children and adults alike (e.g., Baker & Trofimovich, 2005; Flege, 1987; Guion, 2003). Baker and Trofimovich (2005) argue the L1 system of early bilinguals is highly susceptible to restructuring as a result of L2 learning, given than it is still in development. In the present study, the increase in exposure to English

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

coincides with the period of time in which children refine the articulatory gestures needed to produce rhotics, most notably the trill. The fact that rhotics continue to be in the process of acquisition when exposure to English increases may make them more susceptible to English influence and slow the rate of acquisition.

Increased exposure to English may also explain the higher rate of cross-linguistic influence observed in this study as compared to work with Spanish–English preschoolers in the United States; compare the 18% of English-influenced production in this study to the less than 3% in Goldstein *et al*. (2005), Gildersleeve-Neumann *et al*. (2009), and Goldstein and Washington (2001). One potential explanation is that the trill, [r], as an unshared consonant evidences higher error rates than shared sounds in bilingual speech (Goldstein & Washington, 2001). Thus the lack of articulatory experience with the trill as a result of it not being common to both languages is another possible explanation for the observed higher error rates and later age of acquisition than those reported for other groups.

Goldstein and Gildersleeve-Neumann (2012) highlight the difficulties of determining the source of sound substitutions given that "even monolingual children produce errors that are similar to interference in bilinguals" (p. 288). Because previous work with monolingual Spanish children has minimally described the non-target productions of children, it is not possible to determine with certainty the source of these errors; however, given that [ɹ] does not exist in the Spanish phonemic inventory, this likely stems from interaction with English. Other researchers have similarly noted its presence in English-influenced Spanish (Goldstein & Gildersleeve-Neumann, 2012; Ramos-Pellicia, 2007).

Non-target productions are highest in the early elementary grades. The younger speakers in this study substitute sounds from the combined phonetic inventory of the two languages for the trill – taps, alveolar approximants, and combination segments (in the 'other' category) – suggesting that they draw on all available resources. This finding supports multiple accounts of bilingual language acquisition, such as the Unitary System Model, the Speech Learning Model, and Unified Competition Theory, in which the interdependence of the two language systems is central to the theory. As learners gain articulatory control and differentiate the two systems, substitutions decrease, and the phonetic trill is produced with greater frequency.

Willis and Bradley (2008) and Henrikson and Willis (2010) identify duration as a distinguishing feature of taps and trills; the same is observed here. Phonemic trills are consistently longer in duration than phonemic taps. Carballo and Mendoza (2000) highlight the decrease in rhotic duration that occurs as Spanish monolingual children gain greater articulatory control.[4] While mean consonant duration and standard

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

deviations decrease across grade levels for the phonemic tap, as predicted by previous work, the same is not observed for the phonemic trill (see Tables B–E in the 'Appendix'). Productions of Grade 7 participants in the phonemic trill context are of longer duration than those of Grade 1, 3, and 5 participants. As learners gain motor control and are able to produce the phonetic trill, as opposed to developmental variants or substitutions, duration increases, as observed in Carballo and Mendoza (2000).

Goldstein and Washington (2001) note the limitations of retrospective comparisons, such as those being made in the present discussion. While data elicitation methods are similar across previous studies and the current study, methods of analysis are not. Previous reports of monolingual and bilingual rhotic productions have relied on impressionistic as opposed to acoustic analysis (Acevedo, 1993; Bosch Galcerán, 1983; Jimenez, 1987; Linares, 1981). Comparing articulations of this bilingual group to those of a monolingual group on the same task and with the same method of analysis would resolve the issues of retrospective analysis. An additional limitation of the current study is that development is examined via a cross-sectional, not longitudinal analysis. Consequently, developmental trends may be conflated with individual variation. Finally, because data were collected as part of a study with a different focus, a limited number of phonemic trill tokens were collected, and linguistic context (syllable stress, position in word) was not controlled. A more robust sample would allow for examination of the impact of context as well as statistical comparisons of manner of articulation. Investigating the productions of Spanish–English bilinguals longitudinally as exposure to English increases, collecting a larger sample, and controlling for linguistic context (stress, position in word) will advance our understanding of rhotic development in Spanish as well as L2 influence on L1 phonetic development.

Conclusions

The current study addresses some of the limitations of previous research by using acoustic analyses to describe the productions of phonemic taps and trills of school-aged bilingual children, beyond the previously reported age of acquisition for Spanish-speaking children. It has documented lower rates of target production than previously reported, most notably for the phonemic trill. Increased contact with English (L2), whose phonetic inventory does not include a trill, and the corresponding decrease in

[4] Although consonant duration for trills in this study are shorter than those reported in Carballo and Mendoza (2000) with similarly aged learners, this is likely an effect of differing speech styles (Mota Gorriz, 1990). Child participants in Carballo and Mendoza (2000) produced isolated words in response to a visual stimuli, whereas participants in this study were able to select their tokens and also connect their speech.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Spanish input, have been offered as a potential explanation. Although English-like articulations are present, so too are other Spanish phonetic variants, which in many cases serve as developmental substitutions, given their greater ease of articulation. These findings support the notion put forth in the Speech Learning Model (Flege, 1987) that the phonetic systems of bilinguals are dynamic, and argue for continued study of the phonetic systems beyond the point of initial acquisition.

References

Acevedo, M. A. (1993). Development of Spanish consonants in preschool children. *Journal of Childhood Communication Disorders*, *15*, 9–15.

Baker, W., & Trofimovich, P. (2005). Interaction of native- and second-language vowel system(s) in early and late bilinguals. *Language and Speech*, *48*(1), 1–27.

Blecua Falgueras, B. (2001). *Las vibrantes del español: Manifestaciones acústicas y procesos fonéticos* Doctoral dissertation, Universidad Autónoma de Barcelona.

Boersma, P., & Weenink, D. (2015). Praat: doing phonetics by computer [Computer program]. Version 5.4.22, retrieved 8 October 2015 from <http://www.praat.org/>.

Bosch Galcerán, L. (1983). El desarrollo fonológico infantil: Una prueba para su evaluación. *Anuario de Psicología*, *28*(1), 88–114.

Bradley, T. G., & Willis, E. W. (2012). Rhotic variation and contrast in Veracruz Mexican Spanish. *Estudios de Fonética Experimental*, *21*, 43–74.

Carballo García, M. G. (1995). *Estudio de las adquisiciones fonológicas: Análisis acústico de la evolución del fonema* /r̄/. Doctoral dissertation, Universidad de Granada.

Carballo, G., & Mendoza, E. (2000). Acoustic characteristics of trill productions by groups of Spanish children. *Clinical Linguistics & Phonetics*, *41*(8), 587–601.

Colantoni, L. M. (2001). *Mergers, chain shifts and dissimilatory processes: palatals and rhotics in Argentine Spanish*. Doctoral dissertation, University of Minnesota.

Dodd, B., So, L., & Li, W. (1996). Symptoms of disorder without impairment. In B. Dodd, R. Campbell, & L. Worrall (Eds.), *Evaluating theories of language: evidence from disordered communication* (pp. 119–36). London: Whurr.

Fabiano-Smith, L., & Goldstein, B. A. (2010). Phonological acquisition in bilingual Spanish–English speaking children. *Journal of Speech, Language, and Hearing Research*, *53*, 160–78.

Flege, J. E. (1987). The production of 'new' and 'similar' phones in a foreign language: evidence for the effect of equivalence classification. *Journal of Phonetics*, *15*, 47–65.

Fortune, T. W. (2001). *Understanding immersion students' oral language use as a mediator of social interaction in the classroom*. Doctoral dissertation, University of Minnesota.

Gildersleeve-Neumann, C. E., & Davis, B. (1998). *Learning English in a bilingual preschool environment: change over time*. Paper presented at the annual convention of the American Speech-Language-Hearing Association, San Antonio, TX.

Gildersleeve-Neumann, C. E., Kester, E. S., Davis, B. L., & Peña, E. D. (2008). English speech sound development in preschool-aged children from English–Spanish environments. *Language, Speech, and Hearing Services in Schools*, *39*(3), 314–28.

Gildersleeve-Neumann, C. E., Peña, E. D., Davis, B. L., & Kester, E. S. (2009). Effects on L1 during early acquisition of L2: speech changes in Spanish at first English contact. *Bilingualism: Language and Cognition*, *12*(2), 259–72.

Goldstein, B. A., Fabiano, L., & Washington, P. S. (2005). Phonological skills in predominantly English-speaking, predominantly Spanish-speaking, and Spanish–English bilingual children. *Language, Speech, and Hearing Services in Schools*, *36*, 201–18.

Goldstein, B. A., & Gildersleeve-Neumann, C. E. (2012). Phonological development and disorders. In B. A. Goldstein (Ed.), *Bilingual language development and disorders in Spanish–English speakers*, 2nd ed. (pp. 285–309). Baltimore, MD: Paul H. Brookes Publishing.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Goldstein, B. A., & Washington, P. S. (2001). An initial investigation of phonological patterns in typically developing 4-year-old Spanish–English bilingual children. *Language, Speech, and Hearing Services in Schools*, *32*, 153–64.

Guion, S. G. (2003). The vowel systems of Quichua–Spanish bilinguals. *Phonetica*, *60*, 98–128.

Guirao, M., & García Jurado, M. A. (1990). Frequency occurrence of phonemes in American Spanish. *Revue québécoise de linguistique*, *19*(2), 135–49.

Harada, T. (1999). *The acquisition of segmental timing by children in a Japanese immersion program*. Doctoral dissertation, University of California – Los Angeles.

Henrikson, N. C., & Willis, E. W. (2010). Acoustic characterization of phonemic trill production in Jerezano Andalusian Spanish. In M. Ortega-Llebaria (Ed.), *Selected Proceedings of the 4th Conference on Laboratory Approaches to Spanish Phonology* (pp. 115–27). Somerville, MA: Cascadilla Proceedings.

Jimenez, B. C. (1987). Acquisition of Spanish consonants in children aged 3–5 years, 7 months. *Language, Speech, and Hearing Services in Schools*, *18*, 357–63.

Kehoe, M., Trujillo, C., & Lleó, C. (2001). Bilingual phonological acquisition: an analysis of syllable structure and VOT. In K. F. Cantone & M.-O. Hinzelin (Eds.), *Proceedings of the Colloquium on Structure, Acquisition and Change of Grammars: Phonological and Syntactic Aspects* (pp. 38–54). Universität Hamburg, Germany: Arbeiten zur Mehrsprachigkeit.

Linares, T. A. (1981). Articulation skills in Spanish-speaking children. In R. Padilla (Ed.), *Ethnoperspectives in bilingual education research: bilingual education technology* (pp. 363–7). Ypsilanti, MI: Eastern Michigan University Press.

Lipski, J. (1994). *Latin American Spanish*. London: Longmans.

Lleó, C., Kuchenbrandt, I., Kehoe, M., & Trujillo, C. (2003). Syllable-final consonants in Spanish and German monolingual and bilingual acquisition. In N. Müller (Ed.), *(In) vulnerable domains in multilingualism* (pp. 191–220). Amsterdam: John Benjamins.

Maez, L. (1981). *Spanish as a first language*. Doctoral dissertation, University of California – Santa Barbara.

Mason, M. A., Smith, B. F., & Hinshaw, M. M. (1976). *Medida española de articulación*. San Ysidro: San Ysidro School District.

Melgar de González, M. (1976). *Cómo detector al niño con problemas del habla*. Mexico: Trillas.

Mota Gorriz, C. (1990). A study of [r] and [ɾ] in spontaneous speech. *Actes de Xiiéme Congrés International des Sciences Phonetiques*, *4*, 386–9.

Potowski, K. (2004). Student Spanish use and investment in a dual immersion classroom: implications for second language acquisition and heritage language maintenance. *Modern Language Journal*, *88*, 75–101.

Quilis, A. (1993). *Tratado de fonología y fonética españolas*. Madrid: Gredos.

Ramos-Pellicia, M. F. (2007). Lorain Puerto Rican Spanish and 'r' in three generations. In J. Holmquist, A. Lorenzino, & L. Sayahi (Eds.), *Selected Proceedings of the Third Workshop on Spanish Sociolinguistics* (pp. 53–60). Somerville, MA: Cascadilla Proceedings Project.

Rose, M. (2010). Intervocalic tap and trill production in the acquisition of Spanish as a second language. *Studies in Hispanic and Lusophone Linguistics*, *3*, 379–419.

Snow, M. A., & Campbell, R. N. (1985). The acquisition of Spanish phonology by English-speaking children in an immersion program. In T. K. Bhatia & W. C. Ritchie (Eds.), *Progression in second language acquisition* (pp. 19–30). New Delhi: Bahri Publications Ltd.

Willis, E. W. (2007). An acoustic analysis of the 'pre-aspirated trill' in Narrative Cibaeño Dominican Spanish. *Journal of the International Phonetic Association 37*, 33–49.

Willis, E. W., & Bradley, T. G. (2008). Contrast maintenance of taps and trills in Dominican Spanish: data and analysis. In L. Colantoni & J. Steele (Eds.), *Selected Proceedings of the 3rd Conference on Laboratory Approaches to Spanish Phonology* (pp. 87–100). Somerville, MA: Cascadilla Proceedings Project.

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Appendix

Table A

Potential tokens

Tokens of /ɾ/	Tokens of /r/
pájaro 'bird'	*perro* 'dog'
jirafa 'giraffe'	*prana* 'frog'
araña 'spider'	*rinoceronte* 'rhinoceros'
mariposa 'butterfly'	
gorila 'gorilla'	
rinoceronte 'rhinoceros'	
tiburón 'shark'	
oruga 'caterpillar'	
víbora 'snake'	

Table B

Grade 1 productions

	Phonemic tap		Phonemic trill	
Phonetic realization	n	%	n	%
tap	85	63.4	7	15.9
trill	4	3	7	15.9
perceptual tap	10	7.5	1	2.3
continuant tap	11	8.2	1	2.3
tap+	9	6.7	2	4.5
assibilated	2	1.5	3	6.8
alveolar approximant	2	1.5	8	18.2
elided	0	0	2	4.5
other	11	8.2	13	29.5
Total	134		44	
	Average (ms)	Standard deviation	Average (ms)	Standard deviation
Consonant duration	45.9	3.21	75.3	7.2

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table C

Grade 3 productions

	Phonemic tap		Phonemic trill	
Phonetic realization	n	%	n	%
tap	63	57.3	7	16.7
trill	1	0.9	11	26.2
perceptual tap	8	7.3	1	2.4
continuant tap	13	11.8	3	7.1
tap+	8	7.3	5	11.9
assibilated	1	0.9	5	11.9
alveolar approximant	5	4.5	2	4.8
elided	3	2.7	0	0
other	8	7.3	8	19
Total	110		42	
	Average (ms)	Standard deviation	Average (ms)	Standard deviation
Consonant duration	36.8	2.78	70.4	6.85

Table D

Grade 5 productions

	Phonemic tap		Phonemic trill	
Phonetic realization	n	%	n	%
tap	59	58.4	3	7.1
trill	1	1	21	50
perceptual tap	17	16.8	1	2.4
continuant tap	8	7.9	1	2.4
tap+	2	2	6	14.3
assibilated	0	0	3	7.1
alveolar approximant	5	5	1	2.4
elided	0	0	0	0
other	9	8.9	6	15.4
Total	101		42	
	Average (ms)	Standard deviation	Average (ms)	Standard deviation
Consonant duration	32.7	2.67	77.5	7.69

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press

Table E

Grade 7 productions

	Phonemic tap		Phonemic trill	
Phonetic realization	n	%	n	%
tap	43	68.3	4	16
trill	0	0	17	68
perceptual tap	10	15.9	0	0
continuant tap	6	9.5	0	0
tap+	2	3.2	1	4
assibilated	0	0	1	4
alveolar approximant	0	0	0	0
elided	0	0	0	0
other	2	3.2	1	4
Total	63		25	
	Average (ms)	Standard deviation	Average (ms)	Standard deviation
Consonant duration	30.8	3.06	84.65	10.5

https://doi.org/10.1017/S0305000917000460 Published online by Cambridge University Press