Published in final edited form as:
Clin Linguist Phon. 2018 ; 32(4): 392–410. doi:10.1080/02699206.2017.1367037.

Initial Consonant Deletion in Bilingual Spanish-English Speaking Children with Speech Sound Disorders

Leah Fabiano-Smith and
University of Arizona

Suzanne Lea Cuzner
University of Arizona

Abstract

The purpose of this study was to utilize a theoretical model of bilingual speech sound production as a framework for analyzing the speech of bilingual children with speech sound disorders. In order to distinguish speech difference from speech disorder, we examined between-language interaction on initial consonant deletion, an error pattern found cross-linguistically in the speech of children with speech sound disorders. Thirteen monolingual English-speaking and bilingual Spanish and English-speaking preschoolers with speech sound disorders were audio-recorded during a single word picture-naming task and their recordings were phonetically transcribed. Initial consonant deletion errors were examined both quantitatively and qualitatively. An analysis of cross-linguistic effects and an analysis of phonemic complexity were performed. Monolingual English-speaking children exhibited initial consonant deletion at a significantly lower rate than bilingual children in their Spanish productions; however, no other quantitative differences were found across groups or languages. Qualitative differences yielded between-language interaction in the error patterns of bilingual children. Phonemic complexity appeared to play a role in initial consonant deletion. Evidence from the speech of bilingual children with speech sound disorders supports analyzing bilingual speech using a cross-linguistic framework. Both theoretical and clinical implications are discussed.

Keywords

bilingualism; phonology; Spanish; disorder

Introduction

By the year 2024, Latino children will make up 29 percent of children in American schools (National Center for Education Statistics, 2015). States such as Texas, Arizona, and California have historic representation of Latinos due to their proximity to Mexico; however, regional demographics are shifting across the country. Latino children's enrollment in public

Corresponding Author: Leah Fabiano-Smith, PhD, CCC-SLP, University of Arizona, Department of Speech, Language, and Hearing Sciences, 1131 E. 2nd St., Tucson, AZ 85757, Office phone: 520-626-9740, Fax: 520-621-9901, leahfabianosmith@email.arizona.edu.

Declaration of Interest
The authors report no conflict of interest.

school increased in all regions of the United States between 2002 and 2012, increasing by five percentage points in the Midwest and Northeast and seven percentage points in the West and South (National Center for Education Statistics, 2015). Seventy-three percent of Latinos older than five speak Spanish exclusively or in addition to English (Pew Research Center, 2013). These public school demographics motivate the need for speech-language pathologists (SLPs) to have knowledge of Spanish phonological structure in order to categorize difference (i.e., the influence of one language on the other) and disorder (i.e., an underlying speech and/or language-learning disability) in children's speech during evaluation and diagnosis. Unfortunately, the majority of U.S. graduate programs in speech-language pathology remain focused on a monolingual English model (American Speech, Language, and Hearing Association (ASHA), 2015a; 2015b) and 95% of ASHA-certified clinicians report no bilingual skills (ASHA, 2014, p. 2). In the past 36 years, less than 20 peer-reviewed publications have included bilingual children with speech sound disorders (number updated from Kohnert & Medina, 2009). The combination of the lack of training for SLPs, the growing number of Spanish-speaking children in the U.S., and the absence of large, normative databases on bilingual Spanish-English phonological acquisition, results in a paucity of diagnostic approaches for clinicians.

At the foundation of these challenges is the absence of a framework for analyzing the speech of bilingual children with speech sound disorders. Without a theoretical framework, we have no grounding for evidence-based assessment and treatment. To that end, the current study will focus on utilizing a theoretical framework developed for bilingual speech sound perception, the *Processing Rich Information from Multidimensional Interactive Representations* (PRIMIR) (Curtin, Byers-Heinlein, & Werker, 2011) in order to accurately categorize productions that are (1) the influence of one language on the other and (2) true errors that are the result of an underlying speech sound disorder. We examined evidence of between-language interaction in a specific group of bilingual children: Latino preschoolers with speech sound disorders who speak Spanish and English.

Bilingual Phonological Production

Multiple studies have examined speech *perception* in bilingual infants and children (e.g., Bosch & Sebastián-Gallés, 2003; Fennell, Byers-Heinlein, & Werker, 2007; Werker & Byers-Heinlein, 2008; Sundara, Polka, & Molnar, 2008) but speech sound *production* in bilinguals has been studied to a lesser extent (e.g., Fabiano-Smith & Barlow, 2010; Fabiano-Smith & Goldstein, 2010b; Fabiano-Smith, Oglivie, Maiefski, & Schertz, 2015). In addition, while large normative studies on monolingual English-speaking children's speech sound acquisition exist (in addition to readily available standardized tests of phonology for English speakers), normative databases for bilingual phonological acquisition in Spanish-English-speaking preschoolers are smaller and less accessible to clinicians. In order to conceptualize how monolinguals and bilinguals may differ in typical speech sound production, we review current theoretical approaches to the understanding of bilingual speech sound production.

Recent studies have found that Spanish-English-speaking bilingual children demonstrate two separate sound systems, one for each language, that interact with one another systematically and infrequently (e.g., Bunta, Fabiano-Smith, Goldstein, & Ingram, 2009; Fabiano-Smith &

Goldstein, 2010a; 2010b; Fabiano-Smith & Barlow, 2010). This finding has also been observed in bilinguals who speak languages other than English and Spanish (e.g., Holm & Dodd, 1999 [Cantonese]; Johnson & Lancaster, 1998 [Norwegian]; Paradis, 2001 [French]; Keshavarz & Ingram, 2002 [Farsi]; Khattab, 2002 [Arabic]; Brulard & Carr, 2003 [French]; Lleó, Kuchenbrandt, Kehoe, & Trujillo, 2003 [German]) and in other aspects of language such as morphosyntax (e.g., Paradis & Genesee, 1996 [French and English]). Here, we will discuss bilingual phonological production within the *Processing Rich Information from Multidimensional Interactive Representations* (PRIMIR) (Curtin, Byers-Heinlein, & Werker, 2011) model of bilingual speech sound perception. Past studies found that the PRIMIR model of bilingual speech *perception* can be extended to account for differences found in the speech *productions* of bilingual children with speech sound disorders, as compared to their monolingual peers (e.g., Fabiano-Smith & Goldstein, 2010b; Fabiano-Smith & Barlow, 2010; Fabiano-Smith et al., 2015).

Initially, the PRIMIR model was developed to explain how children in general develop sound categories for early word learning (Werker & Curtin, 2005). More specifically, this model posits a multi-layered system that filters input into categories, or "planes," that interact with one another (p. 198). The infant takes in linguistic input, that input is analyzed using methods of statistical learning, patterns are stored, and the infant subsequently stores those units with meanings from the environment. Curtin, Byers-Heinlein, and Werker (2011) then proposed an extension of the PRIMIR model to account for language learning in bilingual infants. In this version of the model, the differences between monolingual and bilingual infants in speech perception center on (1) how incoming input is organized in the representation; specifically, that bilingual infants are able to store information from each language separately and (2) bilingual children will experience different task demands as compared to monolingual children. Therefore, phonological representation will differ between monolinguals and bilinguals. PRIMIR doesn't claim to account for phonological development beyond the emergence of phonemes (p. 493), but what it does posit is a framework for examining the relationship between representation and processing, a framework that is absent from previous models (e.g., *The Interactional Dual Systems Model*, Paradis, 2001; Fabiano-Smith & Goldstein, 2010b). Processing is directed by perceptual biases, task demands, and developmental level, which are all aspects of the language-learning process that differ for bilinguals and monolinguals. Bilinguals and monolinguals have different discrimination abilities for input (e.g., Werker, Weikum, & Yoshida, 2006), bilinguals have input in two different grammars as compared to one, and development will be influenced not only by the learning of those grammars, but also by cognitive, motor, and linguistic development in general (e.g., Byun, Inkelas, & Rose, 2016). Bilingual children show developmental differences in terms of rate of acquisition of certain phonological abilities depending on what language is used to assess what ability (e.g., Fabiano-Smith & Goldstein, 2010a). More specifically, bilingual children may demonstrate abilities in one language but not in the other depending on which language is used for a particular task. The PRIMIR model allows us to go beyond the simple description of separate, but non-autonomous phonological systems, and discuss in detail the underlying processes that lead to developmental differences in speech production.

Recent studies examining the production abilities of bilingual children support using this framework to analyze the phonological errors of bilingual children. Typically-developing bilingual preschoolers demonstrate very little overlap in their use of phonological elements (e.g., Schnitzer & Krasinski, 1994; Paradis, 2001; Fabiano-Smith & Goldstein, 2010b; Fabiano-Smith & Barlow, 2010) and they demonstrate a slower (Fabiano-Smith & Goldstein 2010a; 2010b), commensurate (Fabiano-Smith & Goldstein 2010b; Fabiano-Smith & Barlow, 2010), and faster (Barlow, Branson, & Nip, 2013) rate of development depending on which task is assessed and which measure is being examined. Importantly, in the same group of children, at the same age, a slower, faster, and commensurate rate of acquisition was found on traditional phonological measures such as overall consonant accuracy, phonetic inventory complexity, and occurrence of phonological error patterns (Fabiano-Smith & Goldstein, 2010b; Fabiano-Smith & Barlow, 2010; Fabiano-Smith, Oglivie, Maiefski, & Schertz, 2015). Bilingual children also demonstrated systematic transfer of phonological elements from one language to the other (Paradis, 2001 [stress patterns]; Fabiano-Smith & Goldstein, 2010b [aspiration on initial voiceless stops]; Keffala, Barlow, & Rose, 2016 [syllable structure]), higher accuracy on phonemes shared between their two languages rather than on phonemes specific to one language or the other (Fabiano-Smith & Goldstein, 2010b), as well as language specific phonemes from one language found in the phonetic inventory of the other (e.g., Keshavarz & Ingram, 2002; Fabiano-Smith & Barlow, 2010). This interaction, however, takes place infrequently and only on specific aspects of the phonological system. For example, in Fabiano-Smith and Goldstein (2010b), eight three-year-old typically developing bilingual Spanish-English speaking children were asked to produce phonemes in a single word task. Their productions were transcribed and analyzed for cross-linguistic effects (i.e., bi-directional phonological transfer). In Spanish initial voiceless stops are unaspirated and in English they are aspirated; however, it was found that across most of the bilingual children, initial voiceless stops in Spanish, at times, were being aspirated (e.g., “pato” (duck) /p$^{=}$ato/⇒ [p^{h}ato]) and initial voiceless stops in English were produced, at times, as unaspirated (e.g., “pony” /p^{h}o^{ʊ}ni/⇒ [p$^{=}$o^{ʊ}ni]). This pattern was not observed in the speech of monolingual age-matched Spanish- or English-speaking peers. This interaction occurred at a discrete phonetic level; however, it was systematic in nature, indicating that this sort of production is not a random “mispronunciation” (Schnitzer & Krasinski, 1996, p. 557) but rather, as the authors concluded, a reflection of between-language interaction in bilingual phonological representation.

We propose that in the absence of large-scale studies examining phonological acquisition in bilingual Spanish-English speaking children, we can use the PRIMIR framework to make predictions about between-language interaction based on what the literature reports on typically-developing, Spanish-speaking children. Large-scale studies on every aspect of phonological development in monolingual Spanish-speaking children are not currently available; therefore, some studies discussed here include Spanish-English bilinguals in their samples. Cataño, Barlow, and Moyna (2009) examined the phonetic inventories of 39 typically-developing Spanish-speaking children (both monolingual and bilingual) to determine if typological complexity is acquired in the same way it is acquired in other languages, including English (Dinnsen, Chin, Elbert, & Powell, 1990). Overall, the typology for English determined by Dinnsen et al. (1990) held for Spanish, with one exception: /l/.

All 39 Spanish-speaking children had /l/ present in their phonetic inventories, at the earliest point in development. This was not so for the monolingual English speakers in Dinnsen et al. (1990) who produced /l/ only at the second highest or highest levels of complexity. The phoneme /l/ is common between English and Spanish, but /l/ functions differently in Spanish, as it is included in the frequently produced articles “el” and “la,” has no velar or “dark” /l/ allophone, and is commonly used as a substitute for more complex sounds, even in typically-developing children (Goldstein, 2001; Goldstein, 2005). Because the two languages of Spanish-English bilingual children contrast on the acquisition of this phoneme, clinicians could observe production differences as compared to monolinguals.

Utilization of the PRIMIR model of speech perception in bilinguals to analyze the productions of bilingual children helps provide a theoretical lens through which we can discuss production differences between bilinguals and monolinguals. Using a model that takes into account developmental differences between monolingual and bilingual speech production will allow us to better distinguish *difference* from *disorder* in bilingual phonological development. Further, a theoretical framework that can account for children with speech sound disorders, as well as typically developing children, is particularly strong. If we account for the speech differences in bilingual children and have a clear theoretical rationale motivating how we assess them, we will be at less risk of misidentifying typical children as phonologically disordered. The focus of this study is to look at one particular error pattern, initial consonant deletion, which has been found to be disordered cross-linguistically. We examined this particular error pattern in the speech of monolingual English speakers with speech sound disorders and bilingual Spanish-English-speaking children with speech sound disorders in order to apply the PRIMIR model to the analysis of production errors in both English and Spanish.

Initial Consonant Deletion

Speech-language pathologists consider initial consonant deletion to occur when a child omits the first consonant sound in a word (Bauman-Wangler, 2012) (e.g., the word “sock” /sɑk/ produced as “ock” [ɑk]). Initial syllable deletion (e.g., “potato” /pəte^{i}ɾo^{ʊ}/ produced as “tato” [te^{i}ɾo^{ʊ}]) and cluster reduction or deletion (e.g., “train” /tɹe^{i}n/ produced as “tain” [te^{i}n] and “flores” produced as [oɾes]) are not included in the initial consonant deletion error category (Bernthal & Bankson, 1998). Deletion of complex onsets can occur in the speech of typically-developing children (Bernthal & Bankson, 2000), but here we focus on the omission of initial consonant singletons for analysis and discussion. Deletion of initial consonants greatly reduces intelligibility of speech, making this error pattern in child speech cause for clinical concern (Hodson & Padden, 1981). Initial consonants, because they are the first sound in a word, are perceived more clearly by listeners, unlike medial and final consonants that blend in with the rest of the word (Rieben & Perfetti, 1991). In addition, initial sounds in words are more easily identifiable by someone watching you speak, thus they are easier for people to see, as well as to hear (Fougeron & Keating, 1997). Finally, it is common across languages to use more simplistic sounds as the first sound in a word, making initial sounds easier to produce than medial or final sounds that tend to be more complex (Barlow, 2005). Specifically, simplistic sounds, or unmarked sounds, are early-developing, common across the world’s languages, and easy to articulate (e.g., bilabial plosives)

(Jakobson, 1968). Children should quickly acquire initial consonants because they are generally easier to hear, see, and produce (Faingold, 1990); therefore, omitting them is unexpected in the typical preschool child. Not surprisingly, initial consonant deletion has been observed cross-linguistically in the speech of children with speech sound disorders (e.g., Goldstein, Fabiano, & Iglesias (2004) [Spanish], Petinou and Okalidou (2006) [Cypriot Greek], and Brosseau-Lapré and Rvachew (2013) [French]).

Here, we examine a group of bilingual Spanish-English speaking children with speech sound disorders on the error pattern, initial consonant deletion, using a theoretical framework that we predict will assist clinicians in categorizing production differences from true errors. Specifically, we wanted to observe if between-language interaction occurs in the speech of bilingual children with disorders, or if this phenomena is only found in the speech of typically developing bilingual children.

Predictions

Within the framework of the PRIMIR model (Curtin, Byers-Heinlein, & Werker, 2011), we predicted (1) we would observe between-language interaction in the speech of bilingual children with speech sound disorders evidenced by error patterns that reflect the non-target grammar (i.e., the influence of English grammar on Spanish productions and vice versa) and (2) that differences in phoneme complexity between English and Spanish would trigger the deletion of initial consonants in a way that is predicted by the grammar of each language. Specifically, studies of typically-developing Spanish-English-speaking bilingual children (e.g., Fabiano-Smith & Goldstein, 2010a), found that bilingual preschoolers still have not acquired highly complex phonemes (i.e., later-developing, more difficult to produce, less common across the world's languages) such as the trill /r/, the flap /ɾ/, /l/, /s/, and the approximant /ɹ/ (Jakobson, 1968). As a result, the presence of complex phonemes in a word, in any word position, could lead children to simplify the structure of that word by omitting its initial consonant. In contrast, Spanish-speaking children demonstrate the presence of /l/ in their Spanish phonetic inventories before English speakers (Cataño et al., 2009). Bilingual children may not categorize /l/ in the same way as the Spanish-speakers in Cataño et al. (2009) due to between-language interaction. Therefore, phoneme complexity could predict a higher error rate on words that include highly complex sounds. Between-language interaction could result in children treating sounds that are low in complexity in a given language as high in complexity in that language due to a grammatical conflict with their other language (e.g., treating /l/ as highly complex in *Spanish*).

Our second prediction focuses on the distinction between English and Spanish on the common word shapes (i.e., combinations of syllable types) children are exposed to in each language. Syllable types are the combination of consonants and vowels (or vowels only) in monosyllables (e.g., CV, V, CVC). Word shapes are the combination of syllable types into multisyllabic words (e.g., CV.CVC, CV.CV). According to Lleó (2006), the majority of words that Spanish-speaking children are exposed to consist of disyllables and trisyllables, with few monosyllables in the input. Because of their exposure to, and practice with, complex word shapes, we predict that multisyllabic words should not trigger as many errors on initial consonants in the Spanish productions of bilingual children as they might for the

English productions of monolingual English-speaking children; however, multisyllabic words could be problematic in the Spanish productions of bilingual children whose other language is English (a language that delivers a higher number of monosyllabic words in the input) (Goldstein, 2001). These production patterns in the speech of bilingual children with speech sound disorders could be mistaken for true errors if not analyzed within a theoretical framework that takes into consideration between-language interaction.

Methodology

Participants—Thirteen children participated in the study: Eight bilingual Spanish-English speakers with speech sound disorders (x = 48 months (4;0), range 39–57 months) and five monolingual English-speaking children with speech sound disorders (x = 47 months (3;10), range = 39–57). Monolingual Spanish-speaking children with speech sound disorders were not available for comparison. A Mann-Whitney U test, the nonparametric alternative to the independent samples t-test, found that the two language groups did not differ from one another on age ($z = -.738$, $p = .460$). Children included in this study did not have any history of hearing or neurological impairments based on parent report.

Demographic information on bilingual and monolingual participants with speech sound disorders can be found on Table 1. All children were selected from a larger database of children recorded for an NIH-funded study examining misdiagnosis of speech sound disorders in bilingual Spanish-English speaking children (N = 140). Bilingual children were recorded in the US-Mexico border region of Arizona and were speakers of Mexican Spanish and Southwestern American English. Children attended a federally-funded early child development program or a non-profit preschool. Many children who attended the non-profit preschool received scholarship funding; therefore, SES was variable across those participants despite the requirement of tuition. Because the effects of poverty do not appear to negatively impact phonological acquisition (e.g., Oller, Eilers, Basinger, & Steffens, 1995), children from differing socioeconomic levels were all included in the study.

Children with speech sound disorders and children with speech sound *and* language disorders were included in this study to observe if bilingual children with speech sound disorders omit more initial consonants than their typically developing peers. It is less common to find children who present with speech sound disorders in the absence of language impairment (Shriberg, Tomblin, & McSweeney, 1999); therefore, both types of children with speech sound disorders were aggregated into one group (Table 1). In the absence of well-validated criteria on how to identify speech sound disorders in bilingual preschoolers younger than 4;0, children were identified as having a speech sound disorder using the converging concern approach (Restrepo, 1998). If parents, teachers, *and* a bilingual speech-language pathologist indicated concern in regards to a child’s speech sound production, he or she was included in this category. Percent Consonants Correct-Revised (PCC-R) is reported for individual children on Table 1, and mean PCC-R scores were calculated by group to provide further evidence of disorder. PCC-R for the English of bilingual children was 64.94%, for the Spanish of bilingual children was 64.27%, and was 81.52% for monolingual English speakers. According to Fabiano-Smith and Goldstein (2010a), mean accuracy for typically-developing bilingual Spanish-English speaking children at age 3;0 is 72.31% for English and 65.77% for Spanish. The average age of the children in this study is 4;0, a full year older than the children in Fabiano-Smith and Goldstein (2010a). Also in Fabiano-Smith and Goldstein (2010a), typically-developing three-year-old monolingual English-speaking children demonstrated mean accuracy of 84.1%, similar to the production accuracy of the monolingual four-year-olds in this study.

degree of bilingualism.: Parents provided language input and output information based on a detailed parent interview (e.g., Bedore, Peña, Joyner, & Macken, 2011). Caregivers were asked to estimate, on a given weekday, how many hours their child heard Spanish, spoke Spanish, heard English, and spoke English in the home and at school. Bilingual children were all residing in bilingual environments in the United States, therefore English exposure to some degree outside of the home was assumed. Bilingual children had at least 20% input in both languages in order to be included in the bilingual group (Pearson, Fernández, Lewedeg, & Oller, 1997). Monolingual children resided in the same bilingual community as the bilingual children, but parents reported exposure and use in English only. These children were also not able to provide speech samples in Spanish, as all children in the database were probed for proficiency in both languages. Parental report of language input and output data for some children were unavailable. If it was observed by the research team that children without parent interview data were able to provide speech samples in both languages, they were subsequently included in the bilingual group.

Data Collection

Single word samples were recorded for each child using a picture-naming task. Bilingual children were recorded in both languages, while monolingual children were recorded only in English. The following picture-naming probes were used: *The Assessment of English Phonology* (AEP) (Barlow, 2003), the *Assessment of Spanish Phonology* (ASP) (Barlow, 2003), and the English and Spanish phonology subtests of the *Bilingual English-Spanish Assessment* (BESA) (Peña, Gutierrez-Clellen, Iglesias, Goldstein, & Bedore, 2013). The BESA is the first standardized test of its kind that is normed on bilingual Spanish-English-speaking children, ages 4;0–6;0. Redden and Fabiano-Smith (2013) compared bilingual children's consonant accuracy between these probes and found no significant difference; thus, data from the two probes were aggregated. Both probes are picture-naming tasks of nouns and verbs that target the type and frequency of Spanish and/or English phonemes, syllable types, and clusters. Children who were administered the AEP and ASP produced between 30 and 100 words in each language and children who were given the BESA produced 29. The AEP has 5 opportunities for three-syllable words and the ASP has 43 opportunities for three- and four-syllable words (48 total opportunities). The English phonology subtest of the BESA has six opportunities and the Spanish subtest has 11 opportunities for three- and four-syllable words (17 total opportunities).

To administer the AEP and ASP, a Microsoft© PowerPoint presentation with one picture per slide was presented to the child. The investigator asked the child, "¿Qué es esto?" or "¿Que está pasando?" in Spanish and "What is this?" or "What's happening here?" in English. The child either named the item spontaneously or in imitation. Spontaneous and imitated productions have not been found to differ in accuracy (Goldstein, Fabiano, & Iglesias, 2003). A similar strategy was used for administration of the BESA, the pictures were presented to each child in a binder with one picture per page. Productions were recorded using a wireless lapel microphone (*The Presenter* Model T1-CL) and receiver (Model T3-CL; Shure, Inc., Niles, IL). Recordings were inputted into a Dell Latitude 2100 laptop using Adobe Audition 2.0 and a 16-bit resolution and a sampling rate of 44.1 kHz.

Analyses

phonetic transcription.—Recordings were transcribed by native Spanish and English speakers trained in narrow transcription of the International Phonetic Alphabet (IPA). Data transcription and analysis were performed using the *Logical International Phonetics Program* (LIPP) (Oller & Delgado, 2000). Transcription reliability was averaged across all subjects in our database of children. Inter-rater reliability was performed for all samples that had been fully transcribed at the time of analysis. Mean percent inter-rater agreement for the database (N = 84) reached 92.16% for the Spanish samples and 98.4% for the English samples.

percent occurrence of initial consonant deletion by participant.—Using LIPP, the percent occurrence of initial consonant deletion was calculated for each individual child in both the monolingual and bilingual groups. This analysis did not take into consideration initial syllable deletion or initial cluster deletion or reduction; deletion of initial phonemes only was calculated in this analysis (e.g., “pintura” (painting/picture, paint) produced as [intuɾa] instead of the target [pintuɾa]).

statistical analyses.—In order to compare percent occurrence of initial consonant deletion between the English productions of bilinguals and monolingual English speakers, and between the Spanish productions of bilinguals and monolingual English speakers, the nonparametric alternative to the independent samples t-test, the Mann-Whitney U test, was performed. In order to observe differences between the English and Spanish productions of bilingual children, the nonparametric alternative to the repeated measures t-test, the Wilcoxon test, was performed. Nonparametric statistical tests were used to control for the small sample size in each group which can lead to unequal variances and can result in Type II error.

The following qualitative error analyses were completed by hand using the phonetic transcriptions of the children’s single word samples:

analysis of syllabic complexity.—A qualitative analysis examining syllabic shape was performed on all words where initial consonant deletion was found. The syllable type and word shape of words that triggered initial consonant deletion were examined in order to identify syllabic structures that might motivate this error pattern.

analysis of phonemic complexity.—Words that were produced in error by both monolingual and bilingual children were examined for phonemic complexity. Specifically, we observed if the target words that exhibited initial consonant deletion included complex phonemes (in any word position) as compared to words produced accurately. For example, words that include the Spanish trill /r/, flap /ɾ/, or the English approximant /ɹ/ are considered to be words with high phonemic complexity.

analysis of cross-linguistic effects.—Children's error productions were examined for the following influences of English grammar on Spanish and/or Spanish grammar on English: (1) segmental transfer (i.e., use of a language-specific phoneme in the bilingual child's other language such as [kaɹo] for /karo/ "carro/car"); (2) specific word shapes that trigger initial consonant deletion (as a result of more simplistic word shape preferences in English), and (3) committing errors on sounds that are ranked as low in complexity in one language as high in complexity in that language (e.g., treating the Spanish /l/ as complex in Spanish productions due to its high typological complexity in English). Because this study examines initial consonant deletion exclusively, our analysis of cross-linguistic effects is limited to conflicts in grammatical structure that influence the production of initial consonants.

Results

Percent Occurrence of Initial Consonant Deletion

Phonetic transcription of children's errors on initial singleton consonants can be found in Table 3. In the English productions of bilingual children, initial consonant deletion occurred, on average, 1.6% of the time. In the bilingual children's Spanish productions, it occurred 5.71% of the time. It did not occur at all in the productions of monolingual English-speaking children. A Wilcoxon test confirmed no significant difference between the English and Spanish of bilinguals ($z = -1.15$, $p = .249$) on percent occurrence of initial consonant deletion. A Mann-Whitney U test confirmed no significant difference between monolinguals and bilinguals in English on percent occurrence of initial consonant deletion ($z = -1.792$, $p = .073$); however, a Mann-Whitney U test revealed that there was a significant difference between the productions of monolingual English-speaking children and the Spanish productions of bilinguals. Bilingual children exhibited a significantly higher percent occurrence of initial consonant deletion in their Spanish productions as compared to their monolingual English-speaking peers ($z = -2.08$, $p = .037$).

Out of the eight bilingual children with speech sound disorders, half of them omitted initial consonants in their English productions: Child BD01 omitted initial consonants in the words "vanilla," "guitar," "popcorn," "ladder," and "finger;" child BD02 omitted the /v/ in "vanilla;" child BD03 omitted the /g/ in "guitar," and child BD04 omitted the /θ/ in "thunder." Children BD01, BD02, and BD03 also omitted consonants in their Spanish productions: Child BD01 omitted initial consonants in the words "jugo," "jirafa," and "castillo;" child BD02 omitted initial consonants in the words "bombero," "llorando," "lágrima," "sombrero," "dormido," "nadar," "cachucha," "castillo," and "cadena;" and child BD03 exhibited this error on the word "hueso." In addition, two bilingual children exhibited initial consonant deletion only in their Spanish productions. Child BD07 exhibited initial consonant deletion on the words "lengua" and "jirafa" and child BD08 omitted initial consonants in the words "paraguas" and "llorando." Overall, three bilingual children omitted initial consonants in both languages, two omitted initial consonants in Spanish only, one child omitted initial consonants in English only, and two bilingual children did not omit initial consonants in either language.

A subset of children exhibited a pattern that was not considered to be initial consonant deletion according to the clinical definition (i.e., omission of a word-initial consonant phoneme), but rather omitted the initial syllable of a word and then subsequently omitted the initial consonant of the remaining syllable if it was /l/ or flap /ɾ/. BD02 produced “mariposa” (target: /ma.ɾi.pó.sa/) as [i.kó.sa] and BD01 produced the same target word as [e.pó.ta]. Child BD06 produced “teléfono” (target: /te.lé.fo.no/) as [é.fo.no] and child BD01 produced “bicicleta” (target: /bi.si.klé.ta/) as [i.gjé.ta]. Overall, of these five errors, three children omitted flap /ɾ/, one omitted /l/, and one omitted /s/ (this word also included /l/) when these phonemes became the resulting initial consonants following the deletion of the initial syllable. This aligns with our previously discussed finding that children tend to delete initial consonants when they are typologically complex. Although these instances are not considered to be initial consonant deletion according to its strict definition, when the segment becomes initial, as the result of another phonological pattern, the remaining phoneme then functions as an initial consonant and appears to be evaluated by the child and deleted if too complex.

analysis of syllabic complexity.—Because we did not include instances of initial cluster reduction or cluster deletion as initial consonant deletion, all initial syllables in words in which initial consonant deletion was triggered had singleton onsets. In English, open and closed syllables were both likely to trigger initial consonant deletion (CV = three instances and CVC = five instances). In Spanish, a similar pattern was found, with initial consonant deletion occurring slightly more often on open (more simplistic) than on closed (more complex) syllable types (CV = eight instances and CVC = six instances). It does not appear that complexity of syllable type is motivating initial consonant deletion in either language.

In terms of word shape, there were no errors on words that were monosyllabic. In the bilingual children’s English productions, six instances of initial consonant deletion occurred on a two-syllable word (“guitar” /ɡə.tɑɹ/, “thunder” /θʌn.dɚ/, “ladder” /læ.dɚ/, “finger” /fɪŋ.ɡɚ/, and “popcorn” /pɑp.koʊɹn/) and two errors occurred on the 3-syllable word “vanilla” (/və.nɛ.la/). In the Spanish productions of bilingual children, four instances of initial consonant deletion occurred on two-syllable words (“jugo” /xu.ɣo/, “lengua” /len.ɡwa/, “nadar” /na.ðaɾ/, and “hueso”/we.so/) and 13 errors occurred on three-syllable words (“jirafa” /xi.ɾa.fa/, “castillo” /kas.ti.jo/, “bombero” /bom.be.ɾo/, “llorando” /jo.ɾan.do/, “lagrima” /la.ɣɾi.ma/, “sombrero” /som.bɾe.ɾo/, “dormido” /doɾ.mi.ðo/, “cachucha” /ka.ʧu.ʧa/, “cadena” /ka.ðe.na/, and “paraguas” /pa.ɾaɣ.was/.

Bilingual children omitted initial consonants with greater frequency on three-syllable words in Spanish than in English; however, there are more opportunities to produce multisyllabic words in Spanish. It appears that more complex word shapes (i.e., three-syllable words) in both English and Spanish trigger initial consonant deletion in bilingual Spanish-English-speaking children with speech sound disorders, but two-syllable words (in both English and Spanish) trigger this error sparingly. Interestingly, they performed similarly on two-syllable words in both English and Spanish and only one three-syllable word (“vanilla”) triggered initial consonant deletion in English.

analysis of phonemic complexity.—The results of this qualitative analysis revealed that in their English productions, bilingual children were more likely to omit the initial consonant on words that included /l/, /ɹ/, /v/, or /θ/, all highly complex sounds in English. These sounds in words such as “guitar,” vanilla,” and “thunder” all triggered initial consonant deletion. In their Spanish productions, bilingual children were more likely to omit the initial consonant in a word when that word contained the flap /ɾ/, the spirants /β, ð, ɣ/, the liquid /l/, the fricatives /s, x/, and the affricate /ʧ/ in any position. Notably, these sounds were not necessarily the initial consonant in the word. If the word contained these sounds in any position, initial consonant deletion was triggered. All of these sounds are considered highly complex in Spanish with the exception of /l/ (Fabiano-Smith and Barlow, 2010). For example, “llorando,” “lengua,” “lagrima,” and “paraguas” were words that included complex phonemes, which appeared to trigger initial consonant deletion across children. Therefore, it seems that the typological complexity of the phonemes included in the Spanish target words (Catano, Barlow, & Moyna, 2009) could be driving the initial consonant omission errors.

analysis of cross-linguistic effects.—Three aspects of our data set could be considered evidence of between-language interaction. First, we found bidirectional segmental transfer in the speech of bilingual children. Examples of segmental transfer observed across children included aspirated stops for unaspirated stops (e.g., [t^h] for /t/ and [k^h] for /k/ in Spanish), the Spanish flap [ɾ] for the English approximant /ɹ/ (and vice versa), [v] for /g/, [ɹ] for /l/ in Spanish, [θ] for /s/ in Spanish, and [ɸ] for the English /v/. Secondly, a statistical difference between monolingual English speakers and the Spanish of bilinguals on percent occurrence of initial consonant deletion, while bilingual children demonstrated no statistical difference in error rate across their two languages. It is possible that a higher rate of initial consonant deletion in Spanish could lead to a higher rate of initial consonant deletion in English if phonological information is shared across languages. Thirdly, when a word contained a highly complex phoneme, anywhere in the word, initial consonant deletion was triggered. Bilingual children were treating /l/ as complex in Spanish due to its high complexity in English. The evidence that most clearly illustrates between-language interaction was when the initial syllable of a word was omitted, and the remaining initial consonant was /l/ or flap /ɾ/, that remaining syllable-initial consonant was deleted. Treating the phoneme /l/ as complex (i.e., including it in the inventory of sounds that triggered initial consonant deletion) in Spanish could be evidence for between-language interaction, as /l/ is present phonetically at the very earliest stages of phonological acquisition in Spanish-speaking children (e.g., Catano, Barlow, & Moyna, 2009), but not present in phonetic inventories until the latest stage in English-speaking children (Dinnsen, Chin, Elbert, & Powell, 1990). Bilingual children could be assigning a higher level of complexity to /l/ in Spanish due to the presence of English phonological rules.

Discussion

We utilized a model of bilingual speech perception (PRIMIR; Curtin et al., 2011) as a framework for analyzing the cross-linguistic effects in the speech production of bilingual preschoolers. We found that overall, initial consonant deletion was absent in monolinguals and infrequent in bilinguals with speech sound disorders (1.6% in English and 5.7% in Spanish). Phonological error patterns for typically developing English-speaking children are considered to be of clinical concern if they occur more than 10% of the time by 4;5 years, with the exception of weak syllable deletion, gliding of liquids, and cluster reduction, which occur at higher rates during the preschool years (Haelsig & Madison, 1986, p. 112). Bilingual children in this study exhibited initial consonant deletion at a similar rate to published data on typically-developing monolingual and bilingual children in past studies (2% for English and 4% for Spanish) (Bauman-Waengler, 2012 for English; Goldstein & Iglesias, 1996 for Spanish). Overall, our findings fall in line with what has been documented previously in preschoolers with speech sound disorders (Goldstein & Iglesias, 1996; Petinou & Okalidou, 2006; Brosseau-Lapré & Rvachew, 2013; Rvachew, Leroux, & Brousseau-Lapré, 2014). Our study validates previous work examining monolingual English-speakers with a cohort of Spanish-English speaking children with speech sound disorders.

Of the eight bilingual children with speech sound disorders, three exhibited this error pattern in both languages and three omitted initial consonants in only one language. The more errors a child had, the more likely he or she was to exhibit initial consonant deletion, indicating that percent occurrence of initial consonant deletion could be explained, in part, by severity of disorder (Shriberg & Kwiatkowski, 1982).

Another interesting aspect of these findings is that the Spanish productions of bilingual children differed significantly from the productions of monolingual English speakers on percent occurrence of initial consonant deletion while the two languages of bilingual children did not differ significantly from each other. Why was the error rate in the Spanish productions of bilinguals not significantly higher than the error rate in their English productions? Severity might account for a portion of this phenomenon, but bilingual children with speech sound disorders could also be depending on information that exists in one language to support speech production in the other, resulting in a similar error rate across languages. This finding could be evidence of interaction between the two phonological systems of bilinguals (Curtin et al., 2011).

To support this interpretation, we look to previous studies with similar findings. Fabiano-Smith and Bunta (2012) examined eight bilingual Spanish-English-speaking 3-year-olds on measures of Voice Onset Time (VOT). Bilingual children exhibited VOT measurements that were significantly different from their age-matched monolingual English- and Spanish-speaking peers; however, the bilingual children demonstrated significantly different measures for each of their two languages (i.e., their English VOT value was significantly different from their Spanish VOT value). It is possible that between-language interaction can result in bilingual children using phonological information that exists in one language and applying it to the other language context. When this happens, bilingual children could exhibit production patterns that do not mirror those of their monolingual peers. In the case of

Fabiano-Smith and Bunta (2012), VOT was still distinguishable between English and Spanish, but the contrast was not as distinct as it was between monolingual English and Spanish speakers. In the same way, the error rate in initial consonants in the Spanish of bilinguals in this study could influence the error rate in their English productions, creating less of a distinction in error rate across languages.

We also uncovered that certain complex phonemes appear to trigger initial consonant deletion in English and Spanish. It appeared that bilingual children were treating /l/ as complex in Spanish, when it is typologically low in complexity for Spanish speakers (Cataño, Barlow, & Moyna, 2009). If bilingual children have existing knowledge of the complexity of /l/ in English, they could apply that knowledge to /l/ in their Spanish productions. Bilingual children in this study exhibited both language interaction (e.g., demonstrated a similar frequency of initial consonant deletion in both languages and treated /l/ as complex in Spanish) as well as language separation (i.e., three of the bilingual children omitted initial consonants in one language only), reflecting theoretical models of bilingual phonological representation (e.g., Curtin et al., 2011) and providing a clear framework for analyzing the production patterns for children who are acquiring two phonologies simultaneously. The ability to predict how, and to what extent, the two languages of bilinguals influence one another will aid in differentiating speech difference from speech disorder in this population.

Because this study was exploratory in nature, our theoretical and clinical interpretations are purely speculative and strong caution should be taken when applying these findings directly to the clinical context. It is also a noted weakness that we did not have monolingual Spanish-speaking children with speech sound disorders included for comparison. It appears that initial consonant deletion is an error pattern that both monolingual and bilingual children with speech sound disorders exhibit sparingly; however, it can appear if a phonetic and syllabic context is highly complex. Future studies should examine a larger number of children on a variety of phonological measures in order to observe systematic patterns of between-language interaction, strengthening our theoretical understanding of typical bilingual phonological acquisition.

Clinical Implications

Large group studies should be performed to obtain normative data on initial consonant deletion and other phonological patterns in bilingual Spanish-English speaking children. This study provides a framework for analyzing the production errors of bilingual preschoolers; however, the number of subjects in this study is small and a monolingual Spanish-speaking comparison group is unavailable. For these reasons, these data should not directly inform diagnosis, but rather provide clinicians with a means of approaching the diagnostic process. In order to make an accurate diagnosis of a phonological disorder in bilingual children, SLPs should consider a variety of phonological measures, including percent occurrence of a variety of phonological patterns, measures of consonant and vowel accuracy, phonetic inventory complexity, and measures of speech intelligibility, across both languages. This study provides guidance for the assessment of bilingual children's phonological skills across both languages, which is current best practice for the diagnosis of speech sound disorders in this population.

Acknowledgements

The authors of this study would like to thank the children and families who participated in this study. We would like to acknowledge funding for this project through the National Institutes of Health (NIH) Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) (1R21HD081382–01A1, Leah Fabiano-Smith, P,I.) that funded data collection in Tucson, Arizona. The first author would like to thank the *National Institutes of Health* (NIH) Division of Health Disparities Loan Repayment Program (L60-MD006256) who supported her during the length of this project and The University of Arizona Foundation and the Office of the Vice President for Research, Graduate Studies, and Economic Development Faculty Seed Grant Program for awarding her funding for data collection in Tucson, Arizona. Finally we thank Dr. Yvan Rose and Dr. Jessica Barlow for their comments on an earlier version of the manuscript.

References

American Speech, Language and Hearing Association (2014). Demographic profile of ASHA members providing bilingual services. Retrieved off the World Wide Web on December 2, 2015 at http://www.asha.org/uploadedFiles/Demographic-Profile-Bilingual-Spanish-Service-Members.pdf

American Speech, Language, and Hearing Association (ASHA) (2015a). Historically Black Colleges and Universities and Multicultural/Bilingual Emphasis Programs. http://www.asha.org/practice/multicultural/opportunities/hbi/.

American Speech, Language, and Hearing Association (ASHA) (2015b). CAA Accredited and Candidate Programs. http://www.asha.org/Academic/accreditation/CAA-Accredited-Programs/

Barlow JA (2005). Phonological change and the representation of consonant clusters in Spanish: A case study. Clinical linguistics & phonetics, 19(8), 659–679.16180282

Barlow JA (2003). Asymmetries in the acquisition of consonant clusters in Spanish. The Canadian Journal of Linguistics/La revue canadienne de linguistique, 48 (2), 179–210.

Barlow JA , Branson PE , & Nip IS (2013). Phonetic equivalence in the acquisition of /l/ by Spanish–English bilingual children. Bilingualism: Language and Cognition, 16(01), 68–85.

Bedore LM , Peña ED , Joyner D , & Macken C (2011). Parent and teacher rating of bilingual language proficiency and language development concerns. International Journal of Bilingual Education and Bilingualism, 14(5), 489–511.29910668

Bernthal JE & Bankson NW (1998). Articulation and Phonological Disorders, 4th Edition. Allyn & Bacon: Boston, MA.

Bosch L , & Sebastián-Gallés N (2003). Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. Language and speech, 46(2–3), 217–243.14748445

Brulard I , & Carr P (2003). French-English bilingual acquisition of phonology: one production system or two?. International Journal of Bilingualism, 7(2), 177–202.

Bunta F , Fabiano‐Smith L , Goldstein B , & Ingram D (2009). Phonological whole‐word measures in 3-year‐old bilingual children and their age‐matched monolingual peers. Clinical Linguistics & Phonetics, 23(2), 156–175.19197583

Byun TM , Inkelas S , & Rose Y (2016). The a-map model: articulatory reliability in child specific phonology. Language, 92(1), 141–178.

Cataño L , Barlow JA , & Moyna MI (2009). A retrospective study of phonetic inventory complexity in acquisition of Spanish: Implications for phonological universals. Clinical linguistics & phonetics, 23(6), 446–472.19504400

Curtin S , Byers-Heinlein K , & Werker JF (2011). Bilingual beginnings as a lens for theory development: PRIMIR in focus. Journal of Phonetics, 39(4), 492–504.

De Bot K (2000). A bilingual production model: Levelt's 'speaking' model adapted In Wei L (Ed.) The Bilingualism Reader. p. 420–442.

Fabiano-Smith L , & Barlow JA (2010). Interaction in bilingual phonological acquisition: Evidence from phonetic inventories. International Journal of Bilingual Education and Bilingualism, 13(1), 81–97.20126516

Fabiano-Smith L , & Goldstein BA (2010b). Phonological acquisition in bilingual Spanish-English-speaking children. Journal of Speech, Language, and Hearing Research, 53(1), 160–178.

Faingold ED (1990). The acquisition of syllabic and word structure: Individual differences and universal constraints 1. Language sciences, 12(1), 101–113.

Fennell CT , Byers-Heinlein K , & Werker JF (2007). Using speech sounds to guide word learning: The case of bilingual infants. Child development, 78(5), 1510–1525.17883445

Fougeron C , & Keating PA (1997). Articulatory strengthening at edges of prosodic domains. The journal of the acoustical society of America, 101(6), 3728–3740.9193060

Goldstein B (2001). Transcription of Spanish and Spanish-influenced English. Communication Disorders Quarterly, 23(1), 54–60.

Goldstein BA , & Iglesias A (1996). Phonological patterns in normally developing Spanish-speaking 3-and 4-year-olds of Puerto Rican descent. Language, Speech, and Hearing Services in Schools, 27(1), 82–90.

Haelsig PC , & Madison CL (1986). A study of phonological processes exhibited by 3-, 4-, and 5-year-old children. Language, Speech, and Hearing Services in Schools, 17(2), 107–114.

Hodson BW (1986). The Assessment of Phonological Processes – Revised. Pro-Ed: Austin, Texas.

Holm A , & Dodd B (1999). A longitudinal study of the phonological development of two Cantonese–English bilingual children. Applied Psycholinguistics, 20(03), 349–376.

Jakobson R (1968). Child language, aphasia and phonological universals (Vol. 72). Walter de Gruyter GmbH & Co KG.

Johnson CE , & Lancaster P (1998). The development of more than one phonology: A case study of a Norwegian-English bilingual child. International Journal of Bilingualism, 2(3), 265–300.

Keffala B , Barlow JA , & Rose S (2016). Interaction in Spanish–English bilinguals' acquisition of syllable structure. International Journal of Bilingualism. 1–22.

Khattab G (2002). VOT production in English and Arabic bilingual and monolingual children. Amsterdam Studies in the Theory and History of Linguistic Science Series, 4, 1–38.

Kohnert K , & Medina A (2009, 11). Bilingual children and communication disorders: A 30-year research retrospective. In Seminars in speech and language (Vol. 30, No. 04, pp. 219–233). © Thieme Medical Publishers.19851950

Lleó C , Kuchenbrandt I , Kehoe M , & Trujillo C (2003). Syllable final consonants in Spanish and German monolingual and bilingual acquisition. N. Müller (ed.), 191–220.

Lleó C (2006). The acquisition of prosodic word structures in Spanish by monolingual and Spanish-German bilinguals. Language and Speech, 49 (2). 205–229.17037122

Oller DK , Eilers RE , Basinger D , Steffens ML , & Urbano R (1995). Extreme poverty and the development of precursors to the speech capacity. First Language, 15(44), 167–187.

Paradis J (2001). Do bilingual two-year-olds have separate phonological systems? International Journal of Bilingualism, 5(1), 19–38.

Pearson BZ , Fernández SC , Lewedeg V , & Oller DK (1997). The relation of input factors to lexical learning by bilingual infants. Applied Psycholinguistics, 18(01), 41–58.

Pew Research Center (2013). English proficiency on the rise among Latinos. Retrieved off the World Wide Web on December 2, 2015 at http://www.pewhispanic.org/2015/05/12/english-proficiency-on-the-rise-among-latinos/?utm_expid=53098246-2.Lly4CFSVQG2lphsg-KopIg.0&utm_referrer=https%3A%2F%2Fwww.google.com%2F

National Education Association (NEA). (2007). Truth in labeling: Disproportionality in special education. Retrieved off the World Wide Web on December 2, 2015 at http://www.nea.org/assets/docs/HE/EW-TruthInLabeling.pdf

Rieben L , & Perfetti CA (Eds.). (1991). Learning to read: Basic research and its implications. Hillsdale, NJ: Erlbaum

Schnitzer ML , & Krasinski E (1996). The development of segmental phonological production in a bilingual child: A contrasting second case. Journal of child language, 23(03), 547–571.

Shriberg LD , Austin D , Lewis BA , McSweeny JL , & Wilson DL (1997). The percentage of consonants correct (PCC) metric: Extensions and reliability data. Journal of Speech, Language, and Hearing Research, 40(4), 708–722.

Shriberg L , & Kwiatkowski J (1982). Developmental Phonological Disorders III: A procedure for assessing severity of involvement. Journal of Speech and Hearing Disorders, 47 (3). 256–270.7186561

Shriberg L , & Kwiatkowski J (1994). Developmental Phonological Disorders I. Journal of Speech, Language, and Hearing Research, 37 1100–1126.

Shriberg LD , Tomblin JB , & McSweeny JL (1999). Prevalence of speech delay in 6-year old children and comorbidity with language impairment. Journal of speech, language, and hearing research, 42(6), 1461–1481.

Sundara M , Polka L , & Molnar M (2008). Development of coronal stop perception: Bilingual infants keep pace with their monolingual peers. Cognition, 108(1), 232–242.18281027

Werker JF , & Byers-Heinlein K (2008). Bilingualism in infancy: First steps in perception and comprehension. Trends in cognitive sciences, 12(4), 144–151.18343711

Werker JF , & Curtin S (2005). PRIMIR: A developmental framework of infant speech processing. Language learning and development, 1(2), 197–234.

Werker JF , Weikum WM , & Yoshida KA (2006). Bilingual speech processing in infants and adults. Childhood bilingualism: Research on infancy through school age, 1–18.

Table 1.

Participant demographics

Child ID	Language Group	Age	Sex	Speech and/or Language Disorder	Percent Input English	Percent Input Spanish	Percent Output English	Percent Output Spanish	PCC-R English	PCC-R Spanish	Location of Data Collection	Socioeconomic Status (SES)
BD01	Bilingual	4;0	F	Speech and language	25.50	71.40	28.50	71.40	56.72	50.19	Arizona, USA	Low
BD02	Bilingual	3;3	M	Speech only	40	60	40	60	20.75	52.81	Arizona, USA	Middle
BD03	Bilingual	3;6	M	Speech and language	38.5	61.5	38.5	61.5	67.62	70.5	Arizona, USA	Middle
BD04	Bilingual	4;6	M	Speech and language	36	64	36	64	52.18	52.65	Arizona, USA	Middle
BD05	Bilingual	4;8	F	Speech only	Unavailable	Unavailable	Unavailable	Unavailable	84.62	80.02	Arizona, USA	Unavailable
BD06	Bilingual	4;9	F	Speech and language	Unavailable	Unavailable	Unavailable	Unavailable	70.81	63.72	Arizona, USA	Unavailable
BD07	Bilingual	4;2	M	Speech and language	64.29	35.71	89.29	10.71	78.06	73.68	Arizona, USA	Middle
BD08 *	Bilingual	3;6	F	Speech and language	72	28	100	0	89.01	93.60	Arizona, USA	Middle
MED01	Monolingual English	3;3	M	Speech and language	100	0	100	0	65.24	N/A	Arizona, USA	Middle
MED02	Monolingual English	3;6	F	Speech and language	100	0	100	0	87.99	N/A	Arizona, USA	Middle
MED03	Monolingual English	4;5	F	Speech and language	100	0	100	0	89.83	N/A	Arizona, USA	Unavailable
MED04	Monolingual English	3;10	M	Speech and language	100	0	100	0	81.31	N/A	Arizona, USA	Unavailable
MED05	Monolingual English	4;9	M	Speech only	100	0	100	0	84.31	N/A	Arizona, USA	Middle

* Accurate at the single word level but low intelligibility in connected speech

Table 2.

Means and standard deviations for initial consonant deletion for both language and ability groups

	N	Minimum	Maximum	Mean	Standard Deviation
Monolingual English Speakers with Speech Sound Disorders	5	.00	.00	.00	.00
Bilingual Children with Disorders: English	8	.00	10.64	1.60	3.73
Bilingual Children with Disorders: Spanish	8	.00	18.87	5.71	7.2

Table 3.

Phonetic transcriptions of initial consonant deletion errors by participant

Child ID	Language	Gloss	Adult Target	Child Production
BD01	English	vanilla guitar popcorn ladder finger	/vənɛla/ /gətɑɹ/ /pɑpkoᵒɹn/ /lædɚ/ /fɪŋgɚ/	[ənɛwə] [ətɑɹ] [ɑkoᵒɹn] [æðɚ] [ija]
BD01	Spanish	jugo "juice" jirafa "giraffe" castillo "castle"	/xuɣo/ /xiɾafa/ /kastijo/	[uwo] [aɾaxa] [akijo]
BD02	English	vanilla	/vənɛla/	[ənʌnə]
BD02	Spanish	bombero "firefighter" llorando "crying" lágrima "tear" sombrero "hat" dormido "asleep" nadar "to swim" cachucha "cap" cadena "chain" castillo "castle"	/bombeɾo/ /joɾando/ /laɣɾima/ /sombɾeɾo/ /doɾmiðo/ /naðaɾ/ /katʃutʃa/ /kaðena/ /kastijo/	[ombeðo] [ojanðo] [amelo] [umbelo] [emilo] [alaʔ] [astʃutʃa] [aðena] [atijo]
BD03	English	guitar	/gətɑɹ/	[itaɹ]
BD03	Spanish	hueso "bone"	/weso/	[eso]
BD04	English	thunder	/θʌndɚ/	[ʌndə]
BD07	Spanish	lengua "tongue" jirafa "giraffe"	/leŋgwa/ /xiɾafa/	[eŋgwa] [iðafo]
BD08	Spanish	paraguas "umbrella" llorando "crying"	/paɾaɣwas/ /joɾando/	[ajaɣwə] [oando]