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Research Article

Speech Production Accuracy and Variability in Monolingual and Bilingual Children With Cochlear Implants: A Comparison to Their Peers With Normal Hearing

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Purpose: This study investigates consonant and vowel accuracy and whole-word variability (also called *token-to-token variability* or *token-to-token inconsistency*) in bilingual Spanish–English and monolingual English-speaking children with cochlear implants (CIs) compared to their bilingual and monolingual peers with normal hearing (NH).
Method: Participants were 40 children between 4;6 and 7;11 (years;months; $M_{\text{age}} = 6;2$), $n = 10$ each in 4 participant groups: bilingual Spanish–English with CIs, monolingual English with CIs, bilingual Spanish–English with NH, and monolingual English with NH. Spanish and English word lists consisting of 20 words of varying length were generated, and 3 productions of each word were analyzed for percent consonants correct, percent vowels correct, and the presence of any consonant and/or vowel variability.
Results: Children with CIs demonstrated lower accuracy and more whole-word variability than their peers with NH. There were no differences in rates of accuracy or whole-word variability between bilingual and monolingual children matched on hearing status, and bilingual children had lower accuracy and greater whole-word variability in English than in Spanish.
Conclusions: High rates of whole-word variability are prevalent in the speech of children with CIs even after many years of CI experience, and bilingual language exposure does not appear to negatively impact phonological development in children with CIs. Contributions to our understanding of underlying sources of speech production variability and clinical implications are discussed.

Cochlear implants (CIs) provide access to sound to individuals with severe–profound sensorineural hearing loss (HL). Children born with such HL who receive CIs acquire speech and language with the acoustic signal provided by the device, which is diminished compared to what a child with normal hearing (NH) has access to, thereby affecting speech perception and speech production patterns of young CI users. For children acquiring more than a single language using a CI, the issue is made more complex by virtue of having two phonological systems to master with an impoverished signal. The current study will explore the interplay between two measures of speech production ability (segmental accuracy and whole-word variability) and dual language acquisition in children who use CIs, opening new and interesting avenues of inquiry that have the potential to reveal novel insights into speech/phonological acquisition theory and clinical practice.

Whole-Word Variability

Young children's speech is often described as highly variable, yet the term *variability* describes many different speech phenomena (e.g., motor–kinematic variability, acoustic variability, variable realization of individual phonemes in different words, inconsistency of error patterns). One type of variability that has been reported is *whole-word variability*, which refers to differences in the phonemic realization of a word when produced multiple times. For example, a child might produce the word *sun* as [sʌn], [tʌn], and [dʌn], demonstrating variability in the realization of the initial phoneme. This type of variability has also been referred to in the literature as *token-to-token inconsistency* (Iuzzini-Seigel, Hogan, & Green, 2017; Macrae & Sosa, 2015), *word*

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variability (Macrae, 2013), and simply *inconsistency* (Holm, Crosbie, & Dodd, 2007). Whole-word variability has sometimes been associated with specific subtypes of speech sound disorder, namely *inconsistent phonological disorder* (Dodd, Holm, Crosbie, & McCormack, 2005) and *childhood apraxia of speech* (Iuzzini-Seigel et al., 2017), but has also been observed in children with more general speech sound disorder (Iuzzini-Seigel et al., 2017; Macrae, Tyler, & Lewis, 2014) and in children with typical speech and language development (Ferguson & Farwell, 1975; Macrae & Sosa, 2015; McLeod & Hewett, 2008; Sosa, 2015). To our knowledge, however, whole-word variability has not been investigated previously in bilingual children.

In typical development, whole-word variability has generally been found to decrease with age (Holm et al., 2007; Macrae, 2013; Sosa, 2015), increase with increasing word length and phonological complexity (Leonard, Rowan, Morris, & Fey, 1982; Macrae, 2013; Sosa & Stoel-Gammon, 2012), and be inversely related to expressive vocabulary size (Macrae, 2013; Macrae & Sosa, 2015; Sosa & Stoel-Gammon, 2012). These observations in typical development and observations of whole-word variability in children with speech disorder have led to several hypotheses regarding the underlying sources of this variability, which often differ depending on language status (i.e., typical vs. disorder) and age. For example, children diagnosed with childhood apraxia of speech are thought to have an underlying deficit in speech–motor planning/programming (American Speech-Language-Hearing Association, 2007), and variable production of individual sounds and words is attributed to this motor–speech deficit. In children with typical speech and language development, whole-word variability is thought to arise from one (or a combination) of the following factors: (a) phonological complexity (e.g., word length, syllable structure, age of acquisition of the consonants in the word; Leonard et al., 1982; Macrae, 2013; Sosa & Stoel-Gammon, 2012), (b) immature motor control for speech movements (Kent, 1992), or (c) unstable or "holistic" underlying phonological representations (Ertmer & Goffman, 2011; Ferguson & Farwell, 1975; Sosa & Stoel-Gammon, 2006).

Investigating rates and cross-language patterns of whole-word variability in bilingual and monolingual children with and without CIs, a primary aim of the current study, may offer additional insight into the underlying sources of observed speech production variability in different populations. For example, if the primary source of whole-word variability is immature motor control for speech movements, then bilingual children with and without CIs would be expected to demonstrate relatively commensurate rates of whole-word variability in each language because the speech motor control system is unique to the individual child, not the language spoken. On the other hand, if "holistic" or unstable phonological representations are a primary source of whole-word variability, then children with CIs (both monolingual and bilingual) would be expected to show higher rates of whole-word variability than children with NH due to possible reduced phonemic sensitivity given the nature of the acoustic signal they rely on. This possibility will be discussed in more detail in the following section.

There has been some disagreement in the literature regarding what constitutes typical rates of whole-word variability during the developmental period. For example, Holm et al. (2007) have argued that some whole-word variability in children under the age of 3 years reflects typical development but that significant variability in older children indicates speech disorder. Several recent studies using a similar methodology (Macrae, 2013; McLeod & Hewett, 2008; Sosa & Stoel-Gammon, 2006, 2012), however, have found much higher rates of whole-word variability in typically developing children than that reported in Holm et al. (2007). McLeod and Hewett (2008), for example, found whole-word variability rates between 42% and 78% in a group of sixteen 2- to 3-year olds, whereas Sosa (2015) reported an average of 57% whole-word variability in children aged between 3;6 and 3;11 (years;months). The measure of whole-word variability used in the current work will allow for a direct comparison to results found in these previous studies, thereby contributing to our understanding regarding expected rates of whole-word variability in children with NH and in children who use CIs.

Speech Production in Children Who Use CIs

Current guidelines for candidacy for cochlear implantation by the U.S. Food and Drug Administration allow for receiving a CI as early as 12 months of age, and an increasing number of children are receiving implants as infants and toddlers and are experiencing shorter periods of auditory deprivation. Even after activation of their CI, however, the acoustic signal provided by the device is significantly diminished compared to the auditory input of children with NH, resulting in reduced access to the auditory signal, specifically spectral (i.e., frequency-related) detail (Moberly, Lowenstein, & Nittrouer, 2016). Given these differences in timing of access to the speech signal and the reduced quality of that signal, the postimplant speech development of children with CIs will likely show differences from their peers with NH.

Research documenting speech and language development in monolingual children who use CIs is extensive (Chin & Pisoni, 2000; Ertmer & Goffman, 2011; Ertmer et al., 2002; Faes & Gillis, 2016; Hunter, Kronenberger, Castellanos, & Pisoni, 2017). A repeated finding from these studies is that oral language abilities vary widely among individual children (Boons et al., 2012; Dettman et al., 2016). Likely contributing to this between-children variation in speech and language outcomes within the group of CI users are some well-documented factors that are associated with speech and language outcomes. For example, age of implant activation has been known to have an effect on speech and language outcomes (early implantation yielding improved speech and language outcomes compared to later implant activation) along with length of device use as well as the primary mode of communication (such as aural–oral vs. total communication) and the rehabilitation program provided to the child CI user (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Ertmer, 2007; Miyamoto, Kirk, Svirsky, & Sehgal, 1999; Sarant, Blamey, Dowell, Clark, & Gibson, 2001; Tobey, Geers, Brenner, Altuna, & Gabbert, 2003).

There is ample evidence for the benefits of using the device, but the studies also document delayed phonological acquisition relative to peers with NH (Blamey, Barry, & Jacq, 2001; Chin, 2003; Serry & Blamey, 1999). Moreover, besides the quantitative speech production differences between CI users and their peers with NH, there are some qualitative differences between these groups in the form of unique phonological patterns attested in the speech samples of CI users, such as unique substitution patterns (cf. Chin, 2003), differences in the phoneme inventories (cf. Ertmer & Goffman, 2011), and disproportionally more problems with certain phonemes such as the velar nasal and /t/ compared to their typically developing peers with NH (Flipsen, 2011). Additionally, previous studies have found increased rates of whole-word variability in monolingual children who use CIs (Chin, 2003; Chin & Pisoni, 2000; Ertmer & Goffman, 2011; Faes & Gillis, 2018; Ingram, McCartney, Bunta, Costa, & Freitas, 2001; Moreno-Torres, 2014).

Results from these studies (Ertmer & Goffman, 2011; Faes & Gillis, 2018; Ingram et al., 2001; Moreno-Torres, 2014) are generally consistent; each reports increased rates of whole-word variability in children with CIs when compared to their peers matched on a variety of different variables. Ertmer and Goffman (2011) reported higher rates of variability in children with 2 years of hearing experience relative to their chronological age–matched peers, Ingram et al. (2001) reported significantly higher variability in children with CIs with between 1 and 4 years of hearing experience relative to a peer group matched on phonological ability (i.e., consonant accuracy and phonemic inventory), and Moreno-Torres (2014) found greater whole-word variability in Spanish-speaking children with CIs who had 1–1.5 years of hearing experience compared to a peer group matched on expressive language ability.

Most recently, Faes and Gillis (2018) investigated rates of whole-word variability in the spontaneous speech of nine Dutch-speaking children with CIs from age of activation of the implant (M_{age} = 1;1) up to the age of 5;0. Results were mixed in that the children with CIs demonstrated greater whole-word variability at some ages and less whole-word variability at other ages compared to their age-matched peers with typical hearing. The authors speculated that lower variability rates at some ages could be due to methodological factors (i.e., data for the control group with NH were collected cross-sectionally, whereas data for the children with CIs were collected longitudinally) or the tendency for the children with CIs to produce words with fewer syllables than their peers with NH. This may have impacted overall rates of whole-word variability because increased word length was associated with greater variability in their study and in previous studies (Sosa, 2015). Thus, despite using a variety of different methods for matching participant groups, each of these studies documented higher rates of whole-word variability in children with CIs than in children with NH.

One possible explanation for the observed higher rates of whole-word variability is that children with CIs may have reduced phonemic sensitivity relative to their peers with NH, and this reduction in phonemic sensitivity may impact certain aspects of their speech development. For example, it has been hypothesized that children who use CIs may face significant challenges in developing detailed phonological representations for sounds and words, and several studies have found evidence to support this proposal (Dillon, Burkholder, Cleary, & Pisoni, 2004; Dillon & Pisoni, 2006; Nittrouer, Caldwell-Tarr, Sansom, Twersky, & Lowenstein, 2014). In these studies, nonword repetition (NWR) was used to evaluate the quality of children's phonological representations. Although many levels of linguistic processing are involved in an NWR task (e.g., speech perception, phonological working memory, articulation ability), several researchers have argued that poor NWR ability primarily reflects deficits in the ability to generate "highly refined phonological representations" (Nittrouer et al., 2014, p. 680). In addition, researchers have found atypical substitution patterns in the speech samples of monolingual English-speaking children with CIs (Chin, 2003), atypical order of acquisition of phonemes (Ertmer & Goffman, 2011), and, as previously noted, disproportional problems with specific phonemes (Flipsen, 2011) that may reflect differences in the quality of the underlying phonological representations. If children with CIs do in fact have particular difficulty establishing robust phonological representations and whole-word variability, as previously proposed, is indicative of unstable or "holistic" phonological representations, then higher rates of whole-word variability in children who use CIs would be expected.

Speech Production in Bilingual Children Who Use CIs

According to the Food and Drug Administration, as of 2012, approximately 38,000 children in the United States used CIs (cf. National Institutes of Health/National Institute on Deafness and Other Communication Disorders). According to the U.S. Census, the number of children living in U.S. households in which a language other than English is spoken has also increased with recent 2016 estimates indicating that 21.1% of the population over 5 years of age speaks a language other than English at home (U.S. Census Bureau, 2016). Of these individuals, over half (or 13.1% of the total U.S. population) speak Spanish as the home language. It is therefore likely that the number of Spanish- and English-speaking bilingual children who use CIs in the United States will increase in the coming years. In order to provide appropriate, research-based interventions and recommendations for these children and their families, it is of utmost importance that we have a thorough understanding of the speech and language development of bilingual Spanish- and English-speaking children who use CIs, including how dual language learning and CI use affect speech production accuracy and whole-word variability.

Studies of oral communication outcomes in children with bilingual language exposure who use CIs are limited, and there continues to be concern among families and professionals that exposure to two languages may have a negative impact on speech and language development in one or both of their languages (Deriaz, Pelizzone, & Pérez Fornos, 2014; Teschendorf, Janeschik, Bagus, Lang, & Arweiler-Harbeck, 2011). Existing studies involving bilingual CI users indicate that bilingual CI users are able to achieve bilingual oral proficiency (McConkey Robbins, Green, & Waltzman, 2004; Thomas, El-Kashlan, & Zwolan, 2008) and that they are able to match the language skills of their monolingual peers with CIs given that they receive support in their home language and the language of the majority (cf. Bunta & Douglas, 2013). Furthermore, existing studies document that using both languages may not have detrimental effects on the overall linguistic skills of bilingual CI users (Bunta, Douglas, et al., 2016; Guiberson, 2014). In fact, providing support in the home language may help the development of the language of the majority, as found by Bunta, Douglas, et al. (2016), in that child CI users with Spanish and English support outperform their bilingual peers with English-only support.

As for specific speech patterns produced by young bilingual CI users, studies indicate that bilingual children who use CIs can match the productions of their bilingual peers with NH, such as in voice onset time and prevoicing in each language in word-initial position (Bunta, Goodin-Mayeda, Procter, & Hernandez, 2016). There are, however, unique patterns in the productions of bilingual and monolingual CI users that are reflected in differential productions of postalveolar fricatives and affricates showing effects of both bilingual versus monolingual status and CI use versus NH (Li, Bunta, & Tomblin, 2017). Li et al. investigated frication duration, frication rise time, and centroid frequency as acoustic cues in production in monolingual and bilingual CI users and their peers with NH. All children displayed evidence of relying on these cues, but frication duration and rise time in the Spanish samples of bilingual CI users differed from the patterns attested in their bilingual peers with NH. Also, differences were found in the English frication duration of production patterns of monolingual versus bilingual CI users. Finally, fricative centroid frequency was a more robust place cue for children with NH than for either monolingual or bilingual CI users. So although a few fine-grained analyses of articulatory patterns in bilingual children who use CIs have been reported, to our knowledge, neither overall consonant and vowel accuracy nor whole-word variability has been reported for this population prior to this study.

Thus, this study aims to fill a significant gap in our knowledge by reporting on the speech production abilities of bilingual and monolingual children who use CIs and their peers with NH. The present work also establishes an entirely new line of research by investigating whole-word variability in bilingual children, both with CIs and with NH.

Purpose

The purpose of this study was to investigate speech production patterns, specifically consonant and vowel accuracy and whole-word variability, in bilingual and monolingual children who use CIs and their bilingual and monolingual peers with NH. We sought to answer the following research questions: (a) Do children who use CIs demonstrate differences in accuracy and whole-word variability compared to their peers with NH? (b) Do bilingual children with and without CIs demonstrate differences in accuracy and whole-word variability compared to monolingual peers with the same hearing status? (c) For bilingual children, how do rates of accuracy and whole-word variability compare across their two languages? (d) Is there an association between individual characteristics of CI use, such as age at implantation of the CI and/or duration of use (hearing age [HA]), and accuracy and whole-word variability?

Method

Participants

Forty children in four groups participated in our study: (a) bilingual Spanish- and English-speaking children who use CIs (CIBES; *n* = 10; mean chronological age = 6;6), (b) monolingual English-speaking children who use CIs (CIME; *n* = 10; mean chronological age = 6;6), (c) bilingual Spanish- and English-speaking children with NH (NHBES; *n* = 10; mean chronological age = 5;10), and (d) monolingual English-speaking children with NH (NHME; *n* = 10; mean chronological age = 5;9). Our study was approved by the institutional review board of the University of Houston; the parents of the children provided informed consent, and all of the child participants gave written or verbal assent before taking part in the study. A detailed questionnaire was also completed by the parents or guardians about the child's background relevant for evaluating the speech and language skills of their children (e.g., demographic information, hearing and language background).

Participants for this study were selected from a larger database at the University of Houston that includes samples from each of our participant groups. Participants for this study had to meet the following selection criteria (bilingual criteria apply to children in both bilingual groups, and hearing/CI criteria apply to both CI groups):

1. Bilingual criteria
    a. Be current speakers/users of both Spanish and English (i.e., have receptive and expressive abilities in both languages)
    b. Be able to communicate orally (understand and speak) in their languages
    c. Use each language at least 20% of the time based on parental estimates
    d. Be exposed to both languages before 3 years of age
    e. Have at least 3 years of exposure to both languages

2. Hearing/CI criteria
    a. Have age of implantation under 3 years
    b. Have a minimum of 2.5 years of implant use
3. Typical speech and language and NH criteria
    a. Pass a pure-tone hearing screening at 500, 1000, 2000, and 4000 Hz at 25 dB HL
    b. Scores no more than 1.5 *SD*s below the mean on either the monolingual or bilingual version of the Preschool Language Scale–Fifth Edition (PLS-5; Zimmerman, Steiner, & Pond, 2012)
4. General criteria
    a. Have no concerns or diagnoses of cognitive disorders
    b. Have no speech or language issues other than what is related to HL for CI users

Besides our specific selection criteria listed above, the children in the four groups were matched as closely as possible on demographic and language background variables, such as HA, language exposure, and socioeconomic status. Differences between groups on these variables are reported in the Results section. Furthermore, all participants resided in the same metropolitan area (Houston, TX) and were born in the United States, and the dialect of Spanish for bilingual participants was Mexican. Parental reports indicated that the language typically used in the home for all bilingual participants was Spanish, and as a group, they were rated by their parents to have slightly higher spoken Spanish skills (M = 3.8, SD = 1.19, on a scale from 1 to 5) than spoken English skills (M = 3.1, SD = 1.02). At least some of the family members for each bilingual child were native speakers of Spanish or bilingual as first language learners. Table 1 displays general demographic information for the children in each group and group results of standardized language and speech discrimination testing administered at the time of the collection of the speech production sample. Appendixes A–D provide detailed background information for individual children, including hearing and device information for children with CIs.

All CI users had received or were receiving auditory verbal therapy, which uses oral communication as the only mode of communication, and therefore, the primary mode of communication for all of the participants was aural–oral. Based on parent reports, all of the children used spoken language as their primary mode of communication. Participants received speech-language therapy services either through the Center for Hearing and Speech, a private clinic, or the public school system. Families of the bilingual children with CIs were also encouraged to use both Spanish and English. The form of home language support included having a professional interpreter for all audiological services at the Center for Hearing and Speech and active parental involvement during Spanish auditory–verbal therapy sessions, with the specific intent to teach the parents strategies they could use with their children during daily activities (see also Bunta & Douglas, 2013; Bunta, Douglas, et al., 2016).

Materials and Procedure

Pictures (predominantly black-and-white line drawings) were used to elicit a list of words through a naming task (described in more detail below). The children's speech production samples were captured as standard wave files (.wav, samples at 44.1 kHz and using a 16-bit resolution) using a Marantz PMD 661 MKII Professional Field recorder that records uncompressed sound files onto a Secure Digital memory card. The recorder was positioned on a flat surface (such as a table), and the microphone was directed toward the child approximately 10 in. from the participant to ensure consistency across the different recording sessions. The sound files were subsequently downloaded from the Secure Digital card of the recorder onto a computer for analysis.

Picture-Naming Task: Triple List

The target words were predominantly nouns depicting items familiar to children. Most of the images were black-and-white line drawings chosen specifically for their phonological content. The drawings were appropriate for young children in the age range tested, showed no cultural bias, and have been tested with over 100 children of the same age range and general demographic characteristics (Procter, Bunta, Aghara, & Yavaş, 2015). The elicitation for this study was part of a larger experiment whose goal is to investigate phonological development in bilingual and monolingual children who use CIs and their peers with NH. Prompting occurred using the same technique in both languages and for all samples. First, each child was asked to independently name each picture presented to them after a prompt such as "What is this?" If the target word was not identified based on the first level of prompting, the child was given a description of the object such as "This animal says 'meow.' What is it?" If the child would still not produce the target word, she or he was given a sentence to complete (e.g., "A Siamese is a type of ______."). Finally, if necessary, delayed imitation was used to elicit the target word with a phrase such as "This is a cat. What is it?"

Target words for the variability assessment included 20 Spanish and 20 English words (see Appendix E for word lists). The words varied in length from one to five syllables. The Spanish and English words were balanced as closely as possible on age of acquisition of the consonants or consonant clusters in the words. English consonant and cluster age of acquisition was derived from Smit, Hand, Freilinger, Bernthal, and Bird (1990), and Spanish consonant age of acquisition was derived from Jimenez (1987). Average consonant age of acquisition was 3.59 years for the English words and 3.51 for the Spanish words. The list of 20 words was presented three consecutive times, and each item was coded as spontaneously produced (first three levels of prompting) or elicited via delayed imitation (fourth elicitation level).

The bilingual children were assessed during two separate sessions, one language at a time, to limit code switching and code mixing. The experimenters were proficient in the languages they tested and were knowledgeable of appropriate ways to interact with children from culturally and

Table 1. Participant demographic information and scores on language and speech perception measures by participant group: cochlear implant bilingual English–Spanish (CIBES), cochlear implant monolingual English (CIME), normal hearing bilingual English–Spanish, and normal hearing monolingual English (NHME).

Demographic variable or speech/language measure	CIBES (*n* = 10)	CIME (*n* = 10)	NHBES (*n* = 10)	NHME (*n* = 10)
Age, years;months				
M	6;6	6;6	5;10	5;9
Range	5;7–7;11	5;1–7;11	5;0–6;9	4;6–6;11
SD, months	8.1	11.6	7.6	11.4
Gender				
Male	8	4	5	7
Female	2	6	5	3
Mat. Ed.	1.4	3.7	2.1	3.8
SD	1.6	1.3	1.2	1.1
PLS-5	68.5	77.4	109.8	101.3
SD	15.9	16.9	10.4	13.2
WIPI	43.2	62.0	72.2	90.8
SD	19.5	14.9	27.8	8.0

Note. Mat. Ed. = maternal education on a 6-point scale (0 = *elementary school or no school*, 1 = *some high school*, 2 = *high school degree*, 3 = *some college*, 4 = *college degree*, and 5 = *some graduate school or graduate degree*); PLS-5 = Preschool Language Scale–Fifth Edition standard score (mean standard score = 100, *SD* = 15); WIPI = Word Intelligibility by Picture Identification (percent correct; Ross & Lerman, 1971).

linguistically diverse backgrounds. After obtaining consent and assent, children with NH completed a hearing screening using pure tones at 500, 1000, 2000, and 4000 Hz at 25 dB HL, bilaterally, as previously noted. Children with CIs had their devices checked on the day of the sample. Children were also administered the PLS-5 (Zimmerman et al., 2012) and the Word Intelligibility by Picture Identification test (Ross & Lerman, 1971). For the bilingual children, dual language administration and scoring of the PLS-5 Spanish was used. All of the children produced the 20 words on the word list three times in both languages.

Transcription and Reliability

All words were transcribed using broad phonetic transcription by either a native speaker of the appropriate language or a bilingual speaker with native-like proficiency in the respective language. Interrater transcription reliability was conducted on 25% of the sample, and overall phoneme-to-phoneme agreement exceeded 90% on the samples checked. Transcriptions were also entered into the Logical International Phonetics Program (Oller & Delgado, 2000).

Variability Measure

The variability measure used for the current study is similar to the measure used in previous studies (Holm et al., 2007; Macrae & Sosa, 2015; Sosa, 2015) and can best be described as a modified version of the Inconsistency Assessment, as described by Dodd and colleagues (Dodd, 1995; Dodd, Zhu, Crosbie, Holm, & Ozanne, 2002). Whole-word variability is reported as the percentage of words out of the set of 20 words that are produced with any phonemic variability during the three productions of each word. For the current study, any differences in vowel or consonant phoneme transcription were coded as variable productions; if two of the productions were the same and only one was different (e.g., *zebra* produced as [ziwə], [ziwə], and [zɛbwə]), the "word" was still coded as variable, and no consideration was made for whether any of the productions matched the target (i.e., variable "with hits" vs. variable "no hits"). As an example, a child in the CIBES (i.e., "cochlear implant bilingual English–Spanish") group produced 10 of the 20 words on the Spanish word list with some phonemic variability (e.g., *platano* "banana" variably realized as [blaŋkano], [platanos], and [klantanos]). This child's overall Spanish whole-word variability was recorded as 50% (10/20 words produced with some variability). Variability was calculated separately for the English and Spanish word lists for the bilingual children.

Results

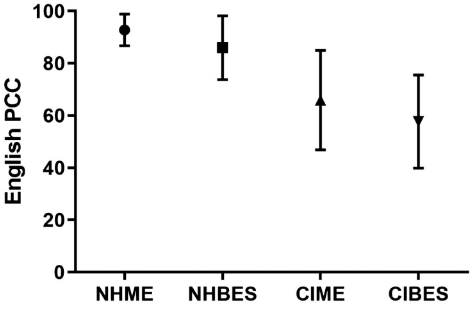
Demographic Variables

In order to determine whether there were overall group differences on key demographic variables, multivariate analysis was conducted with the four participant groups as the fixed factor and chronological age and maternal education as the dependent variables. Results showed chronological age did not differ across the four groups, but there were group differences on the maternal education measure. Post hoc analysis confirmed that the bilingual children with CIs had lower maternal education than both monolingual groups, but there were no differences between bilingual children based on hearing status (i.e., bilingual children with CIs had similar maternal education levels to bilingual children with NH). For children with NH, there were no differences in maternal education between the monolingual and bilingual children. Because factors related to CI use may influence children's speech production ability, independent-samples t tests were conducted for age of implantation and HA. Results showed that the bilingual children had a slightly older age at implantation (M = 25 months, SD = 6.31) than the monolingual children (M = 18.8 months, SD = 6.55), $t(18) = -0.2.16$, p = .045. The two groups did not differ based on duration of CI use; mean HA was 59.4 months (SD = 12.97) for the bilingual children and 53.5 months (SD = 10.93) for the monolingual children.

Accuracy

Mean percent consonants correct (PCC) in English was 89.4% (SD = 9.99) for children with NH and 61.8% (SD = 18.44) for children with CIs. Means and standard deviations for English PCC are displayed in Figure 1. Mean English percent vowels correct (PVC) was 91.55% (SD = 9.2) for children with NH and 80.85% (SD = 11.24) for children with CIs. The main effects of hearing status (CI vs. NH) and language background (bilingual vs. monolingual) were investigated in separate analyses using univariate general linear models with English PCC and English PVC as the dependent variables and hearing status and language background entered as the fixed factors. Due to the group differences in maternal education that were noted previously, maternal education was entered as a covariate. Neither the interaction between hearing status and bilingualism nor the covariate effect of maternal education reached significance for either PCC or PVC; thus, results of the main effect analyses are reported. Given the relatively small sample size and the possibility that insufficient power may mask true group differences, effect sizes (which are less sensitive to larger or smaller sample sizes) are also reported for each of the analyses. There were significant group differences with large effect sizes between children with and without CIs for both PCC, $F(1, 35) = 32.85$, $p < .001$, Cohen's d = 1.86, and PVC, $F(1, 35) = 9.29$, $p < .01$, Cohen's d = 1.01. The effect of bilingualism was not significant for either PCC, $F(1, 35) = 0.56$, p = .46, Cohen's d = 0.37, or PVC, $F(1, 35) = 0.14$, p = .71, Cohen's d = 0.37, and effect sizes were small.

Figure 1. Mean English percent consonants correct (PCC) by group. Error bars represent 1 *SD*. NHME = normal hearing monolingual English; NHBES = normal hearing bilingual English–Spanish; CIME = cochlear implant monolingual English; CIBES = cochlear implant bilingual English–Spanish.



English and Spanish accuracy measures for the bilingual children were compared using a repeated-measures design with the individual language accuracy measures (Spanish PCC and PVC and English PCC and PVC) as the within-subject factors and hearing status (CI vs. NH) as the between-subjects factor. See Figure 2 for mean PCC in each language for bilingual children with CIs and NH. The within-subject effect of language was significant for both PCC, $F(1, 18) = 7.96$, $p < .05$, Cohen's d = 0.84, and PVC, $F(1, 18) = 20.85$, $p < .001$, Cohen's d = 1.10, and effect sizes were medium to large. In both cases, accuracy was higher in Spanish than in English: English PCC, M = 71.85% (SD = 20.78); Spanish PCC, M = 80.4% (SD = 15.84); English PVC, M = 84.05% (SD = 12.17); and Spanish PVC, M = 95.75% (SD = 5.29).

English Whole-Word Variability

Means and standard deviations for English variability for each group are displayed in Figure 3. The main effects of hearing status (CI vs. NH) and language background (bilingual vs. monolingual) on English variability were investigated using a similar analysis as that described for the accuracy data. There was a statistically significant main effect of hearing status, $F(1, 35) = 16.83$, $p < .001$, Cohen's d = 1.32, with a large effect size; children with CI had significantly higher variability scores (M = 63%, SD = 19.36) than children with NH (M = 34%, SD = 24.31). The main effect of language background (i.e., bilingual vs. monolingual) was not statistically significant, $F(1, 35) = 0.40$, p = .529, Cohen's d = 0.49, and the interaction between hearing status and language status was also statistically nonsignificant, $F(1, 35) = 0.91$, p = .347, partial η^2 = .025. There was no statistically significant effect of maternal education on children's variability scores, $F(1, 35) = 1.8$, p = .188, partial η^2 = .049.

In order to determine whether there were cross-language differences in variability in the bilingual children, a repeated-measures design including only the bilingual

Figure 2. Mean English and Spanish percent consonants correct (PCC) for bilingual children with cochlear implants (CI) and normal hearing (NH). Error bars represent 1 *SD*.

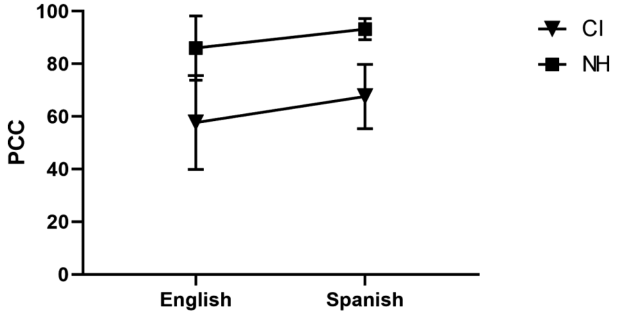
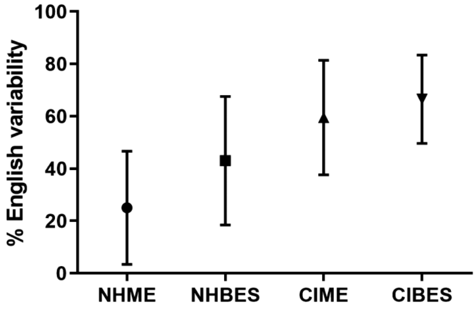
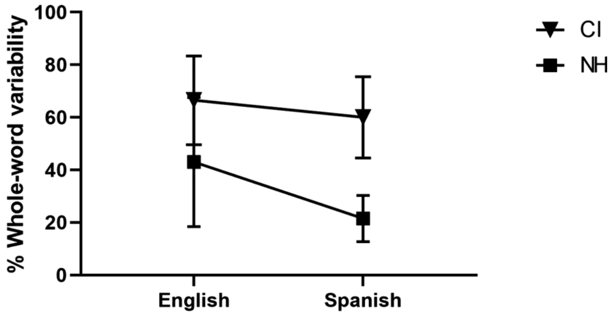


Figure 3. Mean English whole-word variability by group. Error bars represent 1 *SD*. NHME = normal hearing monolingual English; NHBES = normal hearing bilingual English–Spanish; CIME = cochlear implant monolingual English; CIBES = cochlear implant bilingual English–Spanish.



children (both with CI and NH) was used with language (Spanish variability and English variability) as the within-subject factor and hearing status (CI vs. NH) as the between-subjects factor. Results showed that there was a statistically significant within-subject effect of language, *F*(1, 18) = 10.93, $p = .004$, Cohen's $d = 0.77$, with children demonstrating higher variability in English ($M = 54.75\%$, $SD = 23.76$) than in Spanish ($M = 40.75\%$, $SD = 23.24$). The interaction between language and hearing status was statistically nonsignificant, *F*(1, 18) = 3.14, $p = .093$, partial $\eta^2 = .148$. The overall correlation between English and Spanish variability scores for all bilingual children, using a Pearson correlation, was $r = .64$, $p = .002$ (two tailed). See Figure 4 for mean variability in each language for bilingual children with CIs and with NH. Figure 5 displays variability in each language for each child, grouped by hearing status. Although the overall effect of language was significant for the bilingual group as a whole and the Language × Hearing Status interaction was not statistically significant, there are slightly different patterns for individual children in each group. For the children with NH, all but two children (eight out of 10) had higher rates of whole-word variability in English than in Spanish. For the children with CIs, however, only five of the 10 children had higher variability in English than in Spanish. One child had equal variability in each language, and four children had slightly higher variability in Spanish than in English.

Figure 4. Mean English and Spanish whole-word variability for bilingual children with cochlear implants (CI) and normal hearing (NH). Error bars represent 1 *SD*.



Relationship Between CI Use Factors and English Speech Production Measures

The potential influence of age of implantation and HA was investigated using a univariate general linear model with English PCC, PVC, and whole-word variability as the dependent variables; language background (bilingual vs. monolingual) as the fixed between-groups factor; and age of implant and HA entered as covariates. The only statistically significant result from this analysis was that age of implantation had a significant, but modest, effect on all English measures: English whole-word variability, *F*(1, 16) = 6.17, $p = .024$, partial $\eta^2 = .278$; English PCC, *F*(1, 16) = 5.03, $p < .05$, partial $\eta^2 = .239$; and English PVC, *F*(1, 16) = 13.87, $p < .01$, partial $\eta^2 = .464$. The effect of HA was statistically nonsignificant for all measures: English variability, *F*(1, 16) = 0.22, $p = .67$, partial $\eta^2 = .013$; English PCC, *F*(1, 16) = 0.21, $p = .65$, partial $\eta^2 = .016$; and English PVC, *F*(1, 16) = 0.17, $p = .69$, partial $\eta^2 = .01$.

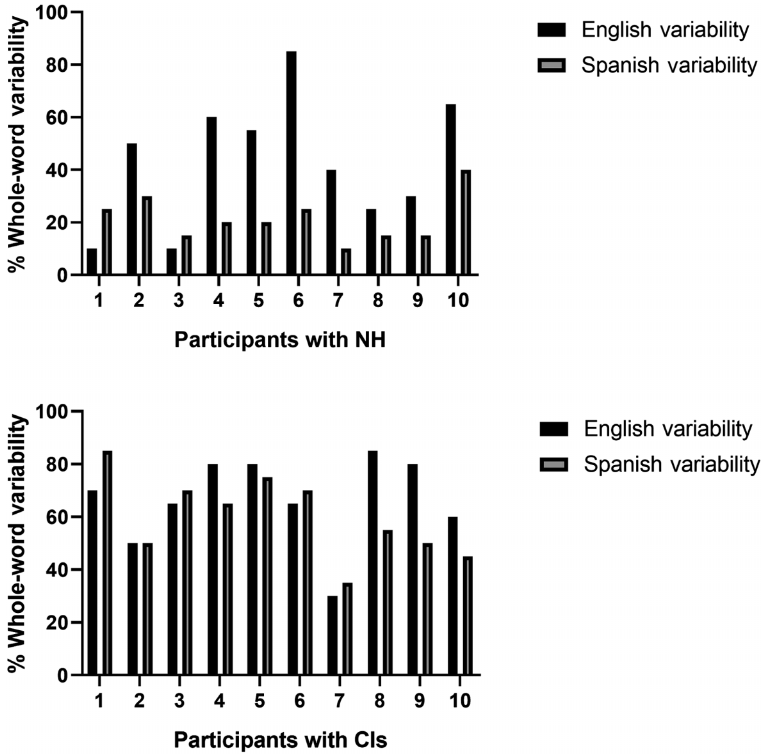
Discussion

Effect of CI Use on Speech Production Measures

The goal of this study was to investigate phonemic accuracy and whole-word variability in bilingual and monolingual children who use CIs and their peers with NH. Our first research question addressed whether the speech production abilities of children, both bilingual and monolingual, who use CIs differ from those of children with NH in the majority language, in this case, English. Based on previous findings, we hypothesized that the children with CIs would have lower accuracy and higher rates of whole-word variability. This hypothesis was confirmed. As a group, the children with CIs had lower English PCC and PVC as well as whole-word variability rates that were almost twice as high as the children with NH. Thus, even after an average of more than 4 years of CI use, these bilingual and monolingual children had not reached consonant or vowel accuracy rates or whole-word production stability rates commensurate with their peers with NH.

Regarding whole-word variability, the current results expand on those of Ertmer and Goffman (2011), who found higher rates of whole-word variability in a group of six children who had received their CIs by 3;0 ($M = 24.8$ months) and who had an average HA of 24 months. They concluded that the higher rates of variability in the children with CIs were due to less "robust hearing experience" (Ertmer & Goffman, 2011, p. 187) and speculated that, with continued CI experience, the children may achieve age-level stability in their production. The children in the current study, however, had an additional 2 years of CI experience (mean HA = 56.5 months) compared to the children in the

Figure 5. English and Spanish whole-word variability for individual children with normal hearing (NH) and cochlear implants (CI).



Ertmer and Goffman study, yet they had not achieved comparable whole-word production stability relative to their chronological age–matched peers. Additionally, when HA was investigated as a potential predictor of whole-word variability in the children with CIs, no statistically significant relationship was found, although earlier age of implantation was associated with lower rates of whole-word variability. In order to investigate whether production stability emerges as a result of increased CI experience within an individual child, a longitudinal study assessing rates of whole-word variability in words of comparable phonetic complexity over time would be needed. Faes and Gillis (2018) began to get at this question in their longitudinal study of children with CIs up to the age of 5;0 and found that whole-word variability decreased as children got older. Because their variability rates were based on spontaneous speech samples, however, they were not able to control for the phonetic complexity of the words.

It is possible, however, that some children with CIs may never achieve age-level speech production stability. Due to the nature of the acoustic signal provided by their CIs, children with CIs may experience specific difficulty establishing robust, stable phonological representations for words (Dillon et al., 2004; Dillon & Pisoni, 2006; Nittrouer et al., 2014). Nittrouer et al. (2014) found that second-graders with CIs (*n* = 55) performed more poorly on an NWR task than age-matched children with NH (*n* = 49). The children's phonemic sensitivity, as measured by a variety of phonological awareness and processing tasks, was found to explain differences in the children's NWR performance. The authors conclude that children with CIs have reduced access to detailed spectral structure in the speech signal during the development period and that this may result in a lack of detailed phonological representations (Nittrouer et al., 2014). Although the current study did not specifically include measures of phonemic sensitivity, previous work has suggested that whole-word variability, even in typical development, may reflect lack of segmental detail or instability of phonological representations (Ferguson & Farwell, 1975; Sosa & Stoel-Gammon, 2006, 2012; Stoel-Gammon, 2011). Sosa and Stoel-Gammon (2012) suggest that whole-word variability and NWR may actually measure the same construct, the robustness of underlying phonological representations. If this is the case, then particularly high rates of whole-word variability in children with CIs may indicate impoverished phonological representations, which could result in difficulty with other language tasks such as vocabulary acquisition and literacy skills, which rely on robust phonological representations (Nittrouer et al., 2014). Nittrouer et al. (2014) propose that NWR may be a useful clinical tool for identifying individual children with CI who may be at the greatest risk for language and literacy difficulties. The current findings suggest that expected rates of whole-word variability may also be a potential clinical marker that could be used to identify children who are at risk for continued language and literacy problems.

Effect of Bilingual Language Experience on Accuracy and Whole-Word Variability

A major contribution of the current study is the analysis of whole-word variability in bilingual populations, something that has not previously been reported. One objective of this study was to determine the effect of bilingualism on consonant and vowel accuracy and whole-word variability in English in children with NH and children who use CIs when matched on hearing status. Given the absence of previously published reports of PCC and PVC or whole-word variability in bilingual children, our hypotheses regarding this question are generated from our general understanding of bilingual phonological development. Previous studies have found that bilingual children generally do not show significant delays in the development of their two phonological systems when compared to their monolingual peers (Fabiano-Smith & Goldstein, 2010b; Gildersleeve-Neumann, Kester, Davis, & Peña, 2008; Goldstein & Washington, 2001), but some differences in certain aspects of phonological development have been observed, for example, differences in the order of acquisition of individual sounds (Fabiano-Smith & Goldstein, 2010a) or in the use of specific phonological error patterns (Bunta, Fabiano-Smith, Goldstein, & Ingram, 2009; Goldstein & Washington, 2001; Holm, Dodd, Stow, & Pert, 1999). Given these findings, we did not anticipate a significant effect of language background (bilingual vs. monolingual) on English accuracy or whole-word variability. Results from the current study were consistent with this expectation. There was no statistically significant effect of language background on overall rates of English phoneme accuracy or whole-word variability, and there was also no interaction between language background and hearing status, suggesting that bilingual children with CIs were not at any greater disadvantage than their monolingual peers who also used CIs in terms of their development of accurate and stable productions of words. Although the observed small effect sizes support this conclusion, these negative results should be interpreted with caution given the small sample size and the large individual differences between children. These results add to a growing body of literature finding that children with communication disorders of various etiologies, including specific language impairment, Down syndrome, and autism spectrum disorder among others, are able to learn two languages at expected levels given their disability and that bilingual language exposure in the home or at school does not negatively impact language acquisition (Bird et al., 2005; Bunta & Douglas, 2013; Gutiérrez-Clellen, Simon-Cereijido, & Wagner, 2008; Paradis, 2009).

Overall, these results support the growing consensus among speech and hearing professionals that families of children with delays or disorders of communication should not be discouraged from raising their child in a bilingual language environment. In fact, considerable evidence suggests that supporting the development of a child's home language not only supports continued first language growth but also strengthens family, cultural, and community ties and does not hinder development of the majority language (Bird et al., 2005; Bunta & Douglas, 2013; Bunta, Douglas, et al., 2016; Ohashi et al., 2012; Reetzke, Zou, Sheng, & Katsos, 2015). Results of this study emphasize that, even in an area that may seem to pose great difficulty for children who have reduced access to acoustic detail in the speech signal, specifically phonological development and the establishment of robust phonological representations, the use of two spoken languages does not appear to hinder the development of the language of the majority.

Relationship Between Whole-Word Variability in the Two Languages of Bilingual Children With and Without CIs

As a group, the bilingual children in this study had more whole-word variability in their English productions than in their Spanish productions, and there was only a moderate, although statistically significant, correlation between rates of variability in each language. Of the various hypotheses regarding underlying sources of variability in children's speech, those that emphasize a motor explanation would predict that whole-word variability in the two languages of bilingual children would be very similar. For example, if whole-word variability is thought to arise from deficits in motor planning, then the expectation would be that the planning deficit would result in similar rates and patterns of whole-word variability in both languages. The statistically significant effect of language on variability rates and the only moderate correlation between variability in each language suggest that the variability observed in these children is not the result of either immaturity in oral–motor control or specific deficits in motor planning or production. This is reinforced by the fact that the children in the study did not have known deficits in areas of speech or language production not associated with their HL.

If a child is having difficulty forming robust phonological representations due to poor spectral resolution of the acoustic cues provided by the CI, this would be expected to affect the establishment of phonological representations in both languages. In the case of children with CIs then, the role of language experience and proficiency might be expected to have a greater influence than for children with NH; with more exposure to and experience using a language, a child may be better able to extract important information from the signal. In recent studies, expressive vocabulary has been identified as the primary predictor of rates of whole-word variability in monolingual children with typical speech and language development (Macrae & Sosa, 2015; Sosa & Stoel-Gammon, 2012). Thus, bilingual children with unbalanced exposure or differing levels of proficiency in each language might be expected to show unequal rates of whole-word variability, with greater stability in their stronger language. As a group, the bilingual children in this study had slightly higher parent ratings of their ability to speak Spanish (M = 3.8 on a scale from 1 to 5) than their ability to speak English (M = 3.1), and they had a somewhat higher percentage of exposure to Spanish (M = 57%) than English (M = 43%). Although these are not direct measures of vocabulary size or overall language proficiency, it suggests that the bilingual children as a group might be more dominant in Spanish, which may have resulted in the lower rates of variability in that language. Additionally, individual differences in proficiency in each language may have contributed to the large individual differences in variability rates that were observed. Future studies should explore the relationship between vocabulary size or other explicit measures of language proficiency and whole-word variability in each of the languages of bilingual children.

Lexical and phonological factors of the test words may also have contributed to different rates of variability in each language. Although every attempt was made to balance the word lists on measures of phonetic complexity, such as word length and age of acquisition of individual consonants in the words, two properties that are known to affect variability in monolingual English-speaking children (Macrae, 2013; Sosa, 2015; Sosa & Stoel-Gammon, 2012), there may have remained differences that were not anticipated. For example, word stress, word frequency, phonotactic probability, and phonological neighborhood density were not controlled.

An important limitation of the current study is the relatively small sample size of 40 participants. Obtaining speech samples from matched groups of young Spanish- and English-speaking bilingual versus monolingual English-speaking CI users is especially challenging considering that few such potential participants exist when using matching criteria and setting the criterion of having functional use of two spoken languages in the bilingual group. Naturally, the fact that the pool of potential participants is small does not alleviate the problem of having a small sample size relative to the heterogeneous nature of the population studied, so caution should be used when interpreting the results. Consequently, it is desirable to collect data from more children in order to draw more definitive conclusions. Finally, our study only analyzed speech production at a single point in time; future research should include longitudinal analyses so that phonological development could be tracked over time in these populations. Despite the limitations of our study, the results contribute to our understanding of the phonological skills of bilingual and monolingual children with NH and with CIs and provide a starting point for future analyses of speech production accuracy and whole-word variability in these populations.

Summary and Conclusion

Our goal with this study was to gain a better understanding of accuracy and whole-word variability in the speech production of bilingual Spanish- and English-speaking children with CIs, their monolingual English-speaking peers with CIs, bilingual children with NH, and monolingual English-speaking children with NH matched on a range of background variables. The children with CIs had lower consonant and vowel accuracy rates than their peers with NH, but the use of two spoken languages did not appear to impact overall accuracy in English. Regarding rates of whole-word variability in children with CIs compared to their peers with NH, the main findings were consistent with and add to findings from previous studies; the children with CIs had significantly higher rates of whole-word variability than the children with NH even, in this case, after almost 5 years of CI experience. Clinicians working with children who use CIs should be aware of this speech production characteristic and may consider incorporating treatment activities that target consistent production of individual words and that may increase the robustness of phonological representations.

This is the first study to investigate whole-word variability in a bilingual population. The primary conclusions that can be drawn from the findings are that bilingualism, per se, does not affect overall rates of whole-word variability, either in children with HL who use CIs or in children with NH. Furthermore, children may demonstrate uneven rates of whole-word variability in each language, supporting the proposal that speech production variability may be more related to overall language experience and proficiency rather than motor immaturity or specific motor speech deficits.

Future studies should investigate additional measures of speech production abilities (e.g., intelligibility) in bilingual children with CIs and incorporate a longitudinal design in order to understand how accuracy and whole-word variability and other phonological skills develop over time as children gain additional CI experience. Additionally, further investigation of associations between whole-word variability and other language tasks related to literacy and academic performance (e.g., vocabulary, phonological awareness) may guide clinicians in their understanding of specific speech production characteristics that might serve as early indicators of potential future difficulties with the development of important speech, language, and literacy skills.

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Appendix A

Background of Monolingual English-Speaking Children With Cochlear Implants

Participant code	CA	Sex	Age at implant	HA	Device type and side	Etiology	Maternal education	Age at hearing loss
14CIME446	5;3.25	M	0;10	4;6	Nucleus 5 (R), Nucleus 6 (L)	Bacterial meningitis	Associate degree	Infant
15CIME423	6;10.21	M	2;0	4;10	AB Harmony (R), AB Neptune (L)	Kidney disease	Some college	Birth
14CIME447	7;11	M	1;1.0	6;10	Med-El Opus 2 (R, L)	Connexin 26	Some high school	Birth
15CIME437	7;7	F	2;2.25	5;5	Nucleus 6 (R, L)	Unknown	Some graduate school	Birth
14CIME256	5;10	F	1;1	4;9	Nucleus 5 (R), Nucleus 6 (L)	Congenital	Graduate degree	Birth
15CIME435	7;7	F	1;7.19	6;0	Med-El Opus 2 (R, L)	Congenital	Graduate degree	Birth
14CIME257	6;5	F	1;10	4;7	Med-El Opus 2 (R, L)	Nerve related	Associate degree	Infant
14CIME408	6;6	F	1;5.0	5;1	Nucleus 5 (R), Nucleus 6 (L)	Unknown	Some college	Birth
14CIME438	5;11	M	1;2	4;9	Med-El Opus 2 (R, L)	Unknown	Bachelor's degree	Birth
15CIME458	5;2	F	2;6	2;7	AB Naída Q70 (R, L)	Unknown	Graduate degree	Birth

Note. CA = chronological age; HA = hearing age; M = male; R = right ear; L = left ear; F = female.

Appendix B

Background of Bilingual Spanish- and English-Speaking Children With Cochlear Implants

Participant code	CA	Sex	Age at implant	HA	Device type and side	Etiology	Maternal education	Age at hearing loss
15CIBES434	7;1 (85)	M	2;4	4;9 (57)	Nucleus 5 (R, L)	Cytomegalovirus	High school	26 mos
15CIBES459	6;3 (75)	M	2;7	3;8 (44)	Nucleus Freedom (R, L)	Connexin 26	Bachelor's degree	Birth
14CIBES407	6;1 (73)	F	2;3	3;10 (46)	Nucleus 5 (R, L)	Ear failed to develop	Elementary school	Birth
15CIBES422	6;9 (81)	M	2;11	3;10 (46)	Nucleus 6 (R, L)	Unknown	Elementary school	18 mos
15CIBES454	6;9 (81)	M	1;7	5;2 (62)	Nucleus 5 (R, L)	Unknown	Some high school	Birth
15CIBES471	5;8 (68)	M	2;0	3;8 (44)	Nucleus 5 (R, L)	Unknown	Elementary school	Birth
14CIBES405	6;11 (83)	M	1;0	5;11 (71)	Nucleus 5 (R), Nucleus Freedom (L)	Unknown	Trade school	Birth
14CIBES439	6;1 (73)	F	2;2.20	3;11 (47)	Nucleus 5	Neuropathic	Some college	Birth
15CIBES402	5;11 (71)	M	2;0	3;11 (47)	Nucleus 5 (R, L)	Unknown	No school	Birth
15CIBES401	7;11 (95)	M	2;0	5;11 (71)	Nucleus 6 (R), Nucleus 5 (L)	Unknown	Unknown	Birth

Note. CA = chronological age; HA = hearing age; M = male; R = right ear; L = left ear; mos = months; F = female.

Appendix C

Background of Monolingual English-Speaking Children With Normal Hearing

Participant code	Chronological age	Sex	Maternal education
16NHME676	5;10.5	M	Bachelor’s degree
16NHME677	5;10.5	M	Bachelor’s degree
16NHME680	4;6.14	M	Bachelor’s degree
16NHME681	6;11.5	M	Graduate degree
16NHME682	6;11.5	M	Graduate degree
16NHME683	6;10.21	F	Graduate degree
16NHME685	6;3.9	M	Bachelor’s degree
16NHME689	4;6.28	M	Some college
16NHME691	4;10.29	F	High school
16NHME694	5;6.1	F	High school

Note. M = male; F = female.

Appendix D

Background of Spanish- and English-Speaking Bilingual Children With Normal Hearing

Participant code	Chronological age	Sex	Maternal education
14NHBES304	6;0	F	High school
14NHBES330	5;0	F	Bachelor’s degree
14NHBES403	6;9	M	Bachelor’s degree
15NHBES512	6;5	M	Some high school
14NHBES318	6;3	M	GED
14NHBES411	5;6	F	GED
14NHBES270	5;2	M	Elementary school
14NHBES264	6;8	M	High school
14NHBES265	5;9	F	High school
14NHBES272	5;3	F	High school

Note. F = female; M = male; GED = General Education Development or General Education Degree.

Appendix E

Target Word Lists in English and Spanish

English	Spanish
1. Fish	1. Pan (bread)
2. Girl	2. Sol (sun)
3. Sheep	3. Flor (flower)
4. House	4. Jabon (soap)
5. Watch	5. Gato (cat)
6. Duck	6. Taza (cup)
7. Scissors	7. Queso (cheese)
8. Zebra	8. Nina (girl)
9. Vacuum	9. Fuego (fire)
10. Jacket	10. Globo (balloon)
11. Penguin	11. Perro (dog)
12. Feather	12. Boca (mouth)
13. Telephone	13. Elefante (elephant)
14. Screwdriver	14. Cuchillo (knife)
15. Bicycle	15. Muneca (doll)
16. Strawberry	16. Platano (banana)
17. Violin	17 Bicicleta (bicycle)
18. Thermometer	18. Mariposa (butterfly)
19. Helicopter	19. Tijeras (scissors)
20. Refrigerator	20. Resbaladilla (slide)