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Empirical Article

Spoken English Language Development in Native Signing Children With Cochlear Implants

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Bilingualism is common throughout the world, and bilingual children regularly develop into fluently bilingual adults. In contrast, children with cochlear implants (CIs) are frequently encouraged to focus on a spoken language to the exclusion of sign language. Here, we investigate the spoken English language skills of 5 children with CIs who also have deaf signing parents, and so receive exposure to a full natural sign language (American Sign Language, ASL) from birth, in addition to spoken English after implantation. We compare their language skills with hearing ASL/English bilingual children of deaf parents. Our results show comparable English scores for the CI and hearing groups on a variety of standardized language measures, exceeding previously reported scores for children with CIs with the same age of implantation and years of CI use. We conclude that natural sign language input does no harm and may mitigate negative effects of early auditory deprivation for spoken language development.

In this paper, we look at the spoken English of Deaf children who use cochlear implants (CIs). The participants in our study are different from those of most studies of children with CIs; however, in that they are also native signers of American Sign Language (ASL), growing up in households with deaf signing parents. Thus, they are growing up as bimodal bilinguals—bilingual in a sign language and a spoken language. As bimodal bilinguals, the appropriate comparison population is other bimodal bilinguals—hearing children growing up in households with deaf signing parents, also known as children of deaf adults ("codas" or "kodas", the latter term used for young participants, or "kids of deaf adults"). Therefore, this paper reports data from both native signers who are deaf children using CIs, as well as hearing kodas. Here, we focus on their spoken English; in other works, we look into more detail at their signing.

As we consider the spoken language development of bimodal bilinguals, we keep in mind general aspects of bilingual language development. In many parts of the world, bilingualism is the norm. Children acquire and use multiple languages, frequently (though not necessarily) reserving each for its associated functions (e.g., one language for home and another language for school). Bilingualism is common, practical, and in fact valuable for many reasons. (For reviews, see Bhatia & Ritchie, 1999; Pearson, 2009.)

Importantly, bilinguals should not be thought of as two monolinguals in one person (Grosjean, 1989). There are many reasons for this caution; here, we focus on the linguistic differences between bilinguals and monolinguals. Studies of language processing show that both languages are active even in contexts for which only one is needed (see works in Kroll & de Groot, 2005). Adult bilinguals code-switch—switching from one language to another, sometimes within the same utterance—and borrow from the lexicon and grammar of one language into another (see, e.g., Bhatt & Bolonyai, 2011 for a discussion of the sociocognitive bases of code-switching, or MacSwan, 2000 for a minimalist account of the syntax of code-switching).

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Some researchers have thought that young children who are exposed to two languages are not able to separate them initially—that they have a unitary linguistic system for the first part of development (e.g., Volterra & Taeschner, 1978). However, researchers now generally reject this notion, showing that very young children are able to separate their linguistic systems (e.g., Genesee, 1989). This does not mean that children keep their languages completely separate all the time. Like adults, children combine their two languages in various ways, sometimes considered to be language "mixing." These bilingualism effects are common and natural (e.g., De Houwer, 1990; Paradis & Genesee, 1996). Sometimes the vocabulary size of each of a bilingual child's languages is lower than that for monolinguals, although the combined vocabulary is equal to or greater than that of monolinguals (Pearson, Fernandez, & Oller, 1993). Sometimes certain aspects of syntactic development show different patterns reflecting the specific language combination (Hulk & Müller, 2000). Bilingual children, like adults, also code-switch (Cantone, 2007).

Given what is known about language development in spoken bilinguals, we turn to bimodal bilinguals. Hearing kodas are linguistically very similar to their spoken bilingual counterparts (Petitto et al., 2001). They also show typical bilingual effects, including code-mixing of different types (Chen Pichler, Quadros, & Lillo-Martin, 2010; Lillo-Martin, Koulidobrova, Quadros, & Chen Pichler, 2012; Lillo-Martin, Quadros, Koulidobrova, & Chen Pichler, 2010; Quadros, Lillo-Martin, & Chen Pichler, in press; Van den Bogaerde & Baker, 2005). However, very little is known about deaf children who are bimodal bilinguals using a sign language and a spoken language.

There is much debate over the usefulness of sign language for deaf children who are using CIs (see Previous Studies of Language Development in Deaf Children With CIs section). Previous studies differ from ours in two important respects: (a) Previous studies of the use of sign language with deaf children using CIs have involved children who are exposed to some form of signing—Manually Coded English, Signed English, sign supported speech, etc.—at school or in intervention programs, not children who have been exposed to a natural sign language like ASL since birth by Deaf, signing parents and (b) Previous studies have compared children who use sign and speech with those who use speech only, thus confounding the effects of sign exposure and bilingualism. Our study looks at children who are native signers and compares deaf children who use CIs with hearing "koda" children growing up with ASL from their Deaf parents.

We believe that bilingual children are the appropriate comparison group for studying language development in deaf children who use both sign language and spoken language. To preview our results, we find that the deaf CI users perform the same as the hearing koda children on standardized measures of English vocabulary, phonology, and syntax. Additionally, both our groups performed well in comparison to published norms.

In the next section, we summarize some of the relevant previous research on language development in deaf children using CIs, and then we move on to details of our study.

Previous Studies of Language Development in Deaf Children With CIs

A number of studies have examined language development in deaf children who use CIs (for recent reviews, see Bouchard, Ouellet, & Cohen, 2009; Peterson, Pisoni, & Miyamoto, 2010; Sarant, 2012). Many studies have considered possible factors associated with varying degrees of success in language-related tasks after implantation. Here, we focus on discussions about the role of sign language exposure in various forms.

The literature is mixed with regard to whether children with sign language input perform worse, better, or no different from children in oral-only programs. Some papers, including the review provided by Peterson et al. (2010, p. 241), report that oral-only language leads to superior results over a combination of sign plus speech:

> Communication mode post-implantation has also been frequently reported to be a factor that contributes to final speech and language outcome, with oral-only communication producing speech and language results superior to those observed in children who use a combination of signing and spoken language.

Some support for this claim comes from the study by Kirk et al. (2002). This study found that rate of receptive language development was the same for oral communication (OC) and total communication (TC) groups of children who were implanted before 3 years of age, but that the OC group was developing more quickly in expressive language. The authors indicate that quantitative differences in language environment might be behind these differences. Holt and Svirsky (2008) found that communication mode accounted for a significant amount of variance beyond age at implant (before 1 year vs. between 1 and 4 years) for one of their measures, word recognition. However, in these studies, communication mode was not the primary variable of interest, and differences between OC and TC groups were limited.

Other studies directly address the question of communication mode and report higher speech and language scores for children in OC versus TC programs. Archbold et al. (2000) report significant differences between OC and TC groups on speech perception and production, but the TC participants were implanted significantly later than the OC, and the study included children with acquired hearing loss—both factors that are generally relevant to spoken language outcomes. Cullington, Hodges, Butts, Dolan-Ash, and Balkany (2000) found that children in an OC setting performed significantly better than children in a TC setting on expressive vocabulary, although not on other measures. Geers, Nicholas, and Sedey (2003) found a significant relationship between classroom communication mode and speech perception even after removing other relevant factors such as child, family, and processor variables. However, the study included children implanted up to age 5 (in the late 1990s), whereas children today are typically implanted much earlier (cf. Dettman, Pinder, Briggs, Dowell, & Leigh, 2007). Tobey, Rekart, Buckley, and Geers (2004) examined speech perception scores as a function of mode of communication and classroom placement and found higher scores for the OC group. However, this study also included children implanted up to age 5, and furthermore, the participants in the OC programs had higher intelligibility scores before implantation, possibly indicating differential placement for independent reasons.

A few works have reported superior language scores, at least in some areas, for children in TC programs. For example, Connor, Hieber, Arts, and Zwolan (2000) reported higher vocabulary scores for their participants in TC programs. Jiménez, Pino, and Herruzo (2009) report superior scores on verbal expression for students using both sign language and spoken language, but better scores on speech perception and intelligibility for oral students (both groups were educated in Spain). Tomasuolo, Fellini, Di Renzo, and Volterra (2010) report that deaf children attending a bilingual school (in Italy) performed better on a picture naming task than those who did not attend a bilingual school. Many more have found no differences due specifically to mode, including study of Niparko et al. (2010) with 188 children who used a variety of modes including speech, sign, and combinations of speech, sign, and other communication systems.

Taken together, the previous studies indicate a wide range of findings, with some evidence for superior performance in spoken language for children in OC programs, but this is not consistent nor by far is it the only or primary factor affecting outcomes.

The signing children included in virtually all studies like the ones cited here typically face two disadvantages with respect to their sign linguistic environment. First, even with early detection, only a small subset of them receive sign language input at a very early age (e.g., in the first 6 months or first year of life). Second, even those who do receive early exposure frequently see a version of signing that is not fluent ASL. One notable exception concerns the children in the Colorado Home Intervention Program, as described by Yoshinaga-Itano, Baca, and Sedey (2010 and other works). These children received early intervention services that included both auditory/oral therapy and weekly sign language instruction from a fluent ASL user (deaf or hearing). The study found that the children with CIs on average demonstrated age-appropriate language levels on receptive syntax at ages 4–7 years and achieved age-appropriate level on expressive vocabulary by 7 years.

One possibility is that language development for children educated in both OC and TC environments is affected by the delay in access to linguistic input and the nature of that input, even for children whose CI is implanted and activated relatively early. It is possible that children who are exposed to a natural sign language from birth will have a more firm foundation for the development of spoken language once the CI is activated. We test this possibility directly in the study reported here.

Participants

General Information

Participants were 25 children tested near Washington, DC, Hartford, CT, and New York, NY. To be eligible for the study, each participant had at least one deaf, signing parent who regularly communicated with the child in ASL. Participants and their families received lunch at the testing site.

Five participants with CIs were born deaf and received a CI following parental decision. Table 1 presents their ages, as well as age of implantation and pseudonyms given for this study. MAX and PAM have unilateral implants, whereas NIK, FIN, and GIA received sequential bilateral implants. All participants with CIs were tested at Gallaudet University in Washington, DC, although two (MAX and PAM) reside in Minnesota. MAX and PAM are siblings. An additional 20 participants were born with typical hearing; we call this group "kids of deaf adults" ("kodas"). Their ages ranged from 4 years 9 months to 8 years 2 months, mean 6 years 0 months.

Twelve participants were tested in Washington, DC (seven kodas and all five of the children with CIs), and five participants were tested in Hartford, CT. Fourteen of these participants attend English-only schools, whereas two kodas (one tested in Washington and one tested in Hartford) and one child with a CI (FIN) have attended at least one school with ASL instruction. Eight participants were tested in New York, NY. Participants in New York attended a bilingual ASL/English school and so received regular classroom instruction in ASL as well as in English.

Socioeconomic Status

Socioeconomic status was estimated by years of mothers' education starting from first grade, where 12 = high school graduate and 16 = bachelor's degree. The range of socioeconomic status of kodas in our study was wide, with some participants' mothers not completing high school, whereas others had graduate degrees. The mean was 14 years or approximately 2 years of college education. Testing locations varied with respect to socioeconomic status: participants at Gallaudet University tended to have parents with graduate degrees, whereas most tested in Connecticut had mothers who completed college, both of which were rarer among mothers in the New York sample.

Among the children with CIs, all of whom were tested at Gallaudet University, we note that the socioeconomic status was very high (Table 1). Although they are far above the norm for deaf children in America, they are consistent with socioeconomic status reported for participants with CIs in other studies. For example, Nicholas and Geers (2008) report that of the 76 children with CIs who participated in their study, 72% had mothers with a 4-year college degree. Therefore, although we do not believe that our results will necessarily generalize to all deaf children, we do believe that they form a reasonable comparison class for other studies of the linguistic and academic achievement of children with CIs in the United States.

Table 1 Individual age, implantation, and socioeconomic status information for participants

Participant	Age of first English testing	Age at first implantation	Years since CI	Mother's education (years)
Children with CIs				
PAM	4 years 0 months	2 years 11 months	1 year 1 month	16
NIK	5 years 5 months	1 year 4 months	4 years 1 month	16
GIA	5 years 7 months	1 year 6 months	4 years 1 month	18
FIN	5 years 8 months	1 year 7 months	4 years 1 month	21
MAX	6 years 4 months	1 year 8 months	4 years 8 months	16
Koda children (*n* = 20)				
Mean	6 years 0 months	N/A	N/A	14
Range	4 years 9 months–8 years 2 months	N/A	N/A	12–21

Note. CI, cochlear implant.

ASL Skills

The participants with CIs in the current study differ from most participants with CIs in other studies in their degree and type of exposure to ASL. Each of our participants had at least one deaf signing parent and so were never without accessible language exposure from birth. The main thesis we are investigating in this paper is how this affects their spoken English language skills. Because of their home environment, we naturally expect that their ASL skills would be superior to typical children with CIs. Unfortunately, ASL skills are rarely tested in children with CIs, so it is not easy to conduct a direct comparison with typical CI groups. Instead, we measured their ASL skills by administering the ASL Receptive Skills Test (RST) (Enns & Herman, 2011).

The ASL RST is adapted from the British Sign Language Receptive Skills Test (Herman, Holmes, & Woll, 1999), testing comprehension of the sign language through a sign-to-picture matching task. Figure 1 presents normed means for ASL according to Enns and Herman (2011), along with individual performance of our CI and koda participants. Although there is variation among individuals, most of our participants, and all of the CI participants, fall near or above the expected reported range of ASL receptive language skills based on scores of deaf children of deaf parents. We take this to confirm that our participants are indeed exposed to, and acquiring, ASL from their deaf parents.

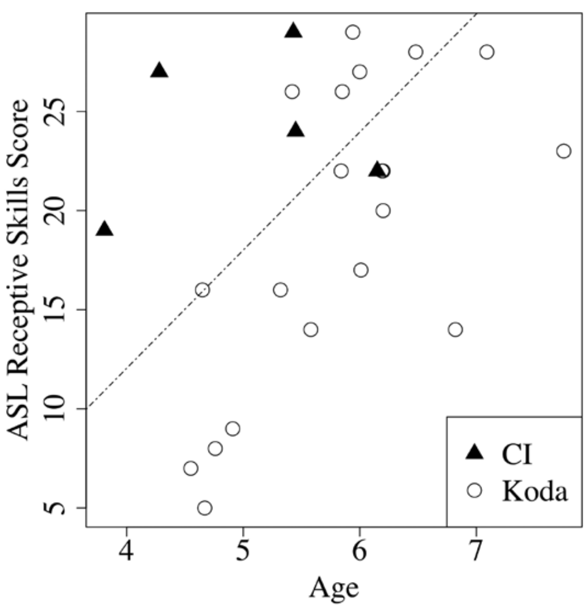

Figure 1 Total correct on the American Sign Language (ASL) Receptive Skills Test by age and hearing status. The dotted line represents a linear regression of the means reported for deaf children of deaf parents, ages 3–8, in the second piloting of the ASL Receptive Skills Test reported by Enns and Herman (2011).

Nonverbal Intelligence

For a measure of nonverbal cognitive abilities, the Leiter-R Nonverbal IQ Screener was administered to all participants. The Leiter is appropriate for children aged 2–21, consists of entirely nonverbal, gestural, instructions and does not involve any expressive language by the participant or the experimenter. The subportion of the full Leiter-R test that we used was the Leiter Brief IQ Screener, which is comprised of four Visualization and Reasoning cognitive subtests: Figure Ground (FG), Form Completion (FC), Sequential Order (SO), and Repeated Patterns (RP). The Leiter Brief IQ Screener takes approximately 25–30 min to administer and can be used as a rapid estimate of global intellectual functioning (Naglieri & Goldstein, 2009). All of our participants (including all five CI children) scored above a standard score of 90, with one exception of a single koda participant, who was unable to finish the test due to inattentiveness.

Methods

All participants were tested at daylong "data collection fairs" held in Washington, DC, Hartford, CT, and New York, NY. Fairs were an effective testing method because they provided a place for families to socialize through the hours while their children were being tested and provided participants the opportunity to interact with other bimodal bilingual children in their free time between tests. Tests of English language were collected on an "English target" fair day where all tests were administered by hearing English speakers, whereas tests of ASL knowledge were collected on a separate day for "ASL target" tests and were administered by deaf or hearing native signers. For all children, the ASL fair was held approximately 1 month earlier than the English fair.

At a given fair, each test was administered by the same experimenters, and so for practical reasons, the order of test administration varied with each child so that multiple children rotating through the tests could be tested in the same day. In addition to the tests we report below, there were additional experiments that were administered but do not have norms for monolingual English development and so will be reported in separate work. Here, we focus on standardized tests that were developed and normed for English-speaking monolingual children: (a) the Preschool Language Scales (PLS), (b) the Expressive Vocabulary Test (EVT), (c) the Goldman–Fristoe Test of Articulation 2 (GFTA-2), (d) the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), and (e) the Index of Productive Syntax (IPSyn).

Preschool Language Scales

The Preschool Language Scales Fourth Edition (PLS-4) (Zimmerman, Steiner, & Pond, 2002) is a measure of general linguistic development in young children. It has two subcomponents, auditory and expressive communication, scored separately. Children's responses take the form of pointing or verbally responding to pictures. Norms are provided for English-speaking children up to age 7 years 11 months. Additionally, Nicholas and Geers (2008) established expected scores on an earlier version of the same test (PLS-3) for children with CIs relative to their age and age of implantation. These expected scores were based on a study of 76 children who received CIs and were educated in an oral/spoken English environment. We calculated PLS scores for the CI children in our study, who have had years of exposure to ASL from birth, to compare with these norms as well as to the koda children in this study.

Expressive Vocabulary Test-2

The EVT-2 (Williams, 2007) can be appropriately administered to participants above age 2 and requires participants to provide names for pictures that are ordered developmentally. The test is untimed, but typically takes less than 15 min. Geren and Snedeker (2009) and Geers, Moog, Biedenstein, Brenner, and Hayes (2009) administered the EVT to orally educated children with CIs, and Geers et al. (2009) also administered the EVT to hearing children of the same age as their CI participants. Our participants are also composed of some participants with typical hearing (kodas) and some participants with CIs but are crucially different from Geers et al. in that our participants are also bilingual in ASL. The EVT allows us to compare the vocabulary of our participants in English with monolingual English peers and children with CIs and no sign language input.

Goldman–Fristoe Test of Articulation 2

The GFTA-2 provides norms for children aged 2–21 on articulation, including sounds placed within words. It takes approximately 20–30 min to administer. Previous researchers who have used the GFTA to measure English scores of children with CIs include Connor et al. (2000), Schorr, Roth, and Fox (2008), and Spencer and Guo (2013). Connor et al. in particular include both children who were educated in an OC environment as well as children who were educated in TC classrooms.

Dynamic Indicators of Basic Early Literacy Skills

The DIBELS sixth edition (Good, Laimon, Kaminski, & Smith, 2007) provides measures of development of skills important for literacy. We administered the Initial Sound Fluency test at the Kindergarten level, section 2, which contained 16 test items, divided into 4 blocks. Each block introduced four items (e.g., "This is a mirror, eagle, bench, girl" while pointing to pictures) and asked the child to point to, for example, "Which picture begins with /m/?" The same method of using four pictures and asking which begins with a particular initial sound was one of the measures tested on children with CIs by James, Rajput, Brinton, and Goswami (2008) (their "phoneme test"). Although the GFTA tested children's expressive phonological development, the DIBELS Initial Sound Fluency test measures children's metalinguistic phonological abilities.

Index of Productive Syntax

The IPSyn provides a list of 56 syntactic and morphological structures to check for in a spontaneous speech sample of 100 utterances. Although originally established for children aged 2–4 (Scarborough, 1990), the IPSyn is frequently used as a measure of the speech of older children with CIs and other nontypically developing populations. In particular, the years of language experience of most young children with CIs, including the children in our sample, is not more than approximately 4 years, near the higher end of the appropriate ages on which to calculate monolingual English IPSyn scores.

Three of the CI participants (GIA, NIK, and FIN) are enrolled in a longitudinal study for which free play samples are regularly collected. Samples from their free play sessions in closest proximity to the language fairs (never more than 1 month away) were used to calculate IPSyn scores. For a fourth CI participant, PAM, the IPSyn was calculated on a sample of speech from a storytelling session during the fair in which there was also significant spontaneous interaction with experimenters. Her total usable utterances summed to 50, so her IPSyn score was calculated via extrapolation according to the table in Scarborough (1990). MAX participated in the same fair, but he was older and more focused on the tests, so his recorded speech primarily consisted of what was elicited by experimental materials. We judged the speech in these settings to be too contrived for an appropriate IPSyn analysis, and because we did not otherwise have samples of free play sessions with him, we did not calculate and do not report IPSyn scores for MAX.

Results

Preschool Language Scales

The PLS provides both age equivalence scores, as well as standard scores for Expressive Communication and Auditory Comprehension subcomponents. Because the test only provides age equivalence scores up to 6 years 11 months, participants who were older than 6 years 11 months at testing (all of whom were kodas) were removed from PLS analysis. Age equivalence scores for the CI group and their hearing koda peers were entered into a combined linear regression, with age and hearing status (CI vs. koda) as factors. As expected, PLS age equivalent scores were significantly predicted by age ($\beta = 0.76$, $p < .001$), but, importantly, there was no significant effect of hearing status ($\beta = 0.19$, $p = .55$; Figure 2). Table 2 presents expected scores for individual subcomponents of the PLS for children with CIs according to Nicholas and Geers (2008). These scores are based on age at implantation and current age, using PLS-3 scores from 76 children

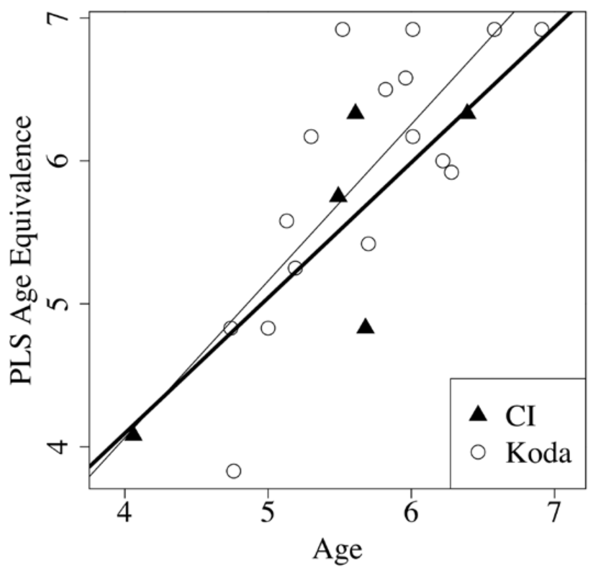

Figure 2 Preschool Language Scales (PLS) age equivalence scores for cochlear implant (CI) and koda participants. The individual linear regression of CI scores by age is represented by the darker line and kodas with the lighter line.

with CIs who were educated in an oral-only environment with no sign language at home. Four of our CI participants scored above expected figures for both subtests, and all participants scored above the expected score when scores from both subcomponents are combined.

Expressive Vocabulary Test

Like the PLS, results from the EVT provide age equivalences. Participants in our study, who were between the ages of 4 years 0 months and 8 years 3 months, all scored between 4 years 0 months and 9 years 0 months age equivalence (Table 3). Age equivalence scores for the CI group and their hearing koda peers were entered into a combined linear regression. Again, as expected, the EVT age equivalent scores were significantly predicted by age ($\beta = 0.86$, $p < .001$), and again, there was also no significant effect of hearing status ($\beta = 0.001$, $p = .997$; Figure 3).

Goldman–Fristoe Test of Articulation 2

The GFTA-2 provides standard scores for participants, with 100 considered to be the normed average. In our study, the 20 koda participants had scores ranging from 86 to 116 (mean = 107.9, standard deviation

Table 2 Predicted (Nicholas & Geers, 2008) and actual Preschool Language Scales scores by age of implantation

		Predicted standard score	Actual standard score	Predicted standard score	Actual standard score
Participant	Age at implant (months)	EC	EC	AC	AC
PAM	35	60	92	68	101
NIK	16	89	94	93	98
GIA	18	83	105	88	102
FIN	19	80	87	86	75
MAX	20	77	93	85	97

Note. EC, expressive communication subcomponent; AC, auditory comprehension subcomponent.

Table 3 Individual Expressive Vocabulary Test standard scores for cochlear implant participants

Participant	Age	Expressive Vocabulary Test standard score
PAM	4 years 0 months	110
NIK	5 years 5 months	112
GIA	5 years 7 months	108
FIN	5 years 8 months	100
MAX	6 years 4 months	90

Table 4 Individual GFTA-2 scores for cochlear implant participants

Participant	Age	GFTA
Standard score		
NIK	5 years 5 months	109
GIA	5 years 7 months	112
FIN	5 years 8 months	100
MAX	6 years 4 months	102

Note. GFTA-2, Goldman–Fristoe Test of Articulation 2.

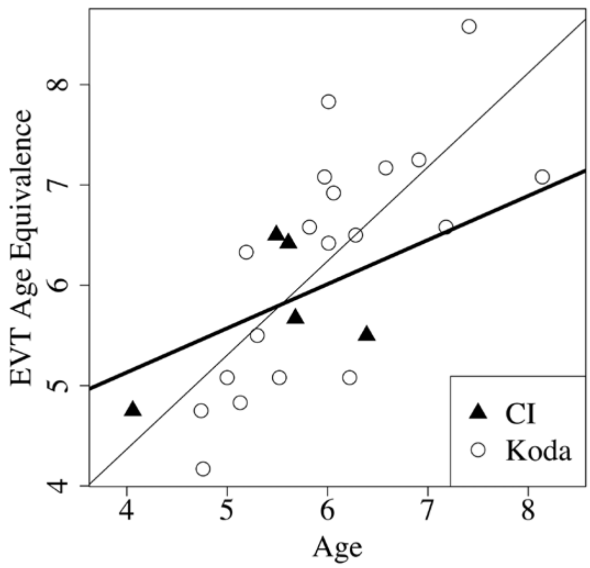

Figure 3 Expressive Vocabulary Test (EVT) age equivalence scores of participants relative to age. The individual linear regression of cochlear implants scores by age is represented by the darker line and kodas with the lighter line.

[SD] = 7.5), which places 100% of the participants within the typical range. Compared to their hearing peers, CI participants performed very well, as can be seen in Table 4. Each of the four[1] participants who was administered the GFTA performed within the normal range, within 1 SD above or below the mean of their hearing koda peers.

Dynamic Indicators of Basic Early Literacy Skills

In the DIBELS Initial Sound Fluency test, participants are scored on a scale of 0–16 for the number of trials they answered correctly. Among our participants, 18 scored 12 points or above (75% correct) and only 7 scored below (one did not take the test). Unfortunately, there are no age equivalence or standard scores for this subtest, but raw scores for the CI group and their hearing koda peers were entered into a combined linear regression. Scores were significantly predicted by age ($\beta = 4.01$, $p < .001$), again with no significant effect of hearing status ($\beta = 1.30$, $p = .43$; Figure 4).

Index of Productive Syntax

Table 5 presents IPSyn scores for each of our four CI participants for which we were able to calculate an IPSyn. Each had an IPSyn score greater than 75, the score which has been considered "successful" for CI users of the same age (see Geers, 2004 and discussion below).

Discussion

In comparison to test norms and to their typically hearing bilingual peers (kodas), from whom they were indistinguishable, the native signing CI participants

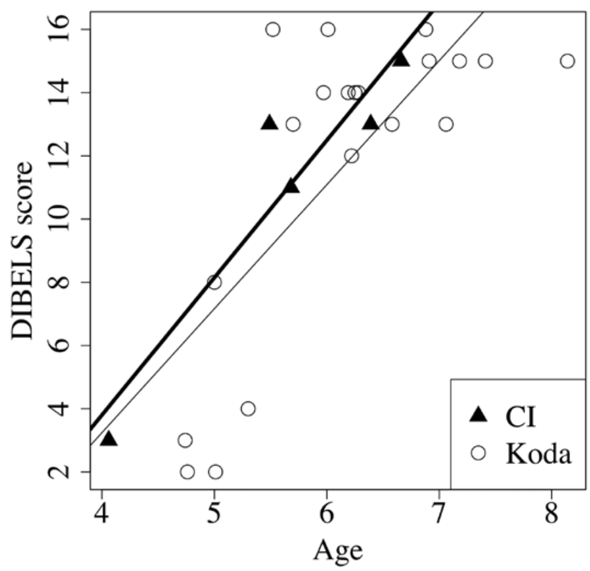

Figure 4 Raw Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Initial Sound Fluency scores of cochlear implant (CI) and koda participants relative to age. The individual linear regression of CI scores by age is represented by the darker line and kodas with the lighter line.

Table 5 Individual IPSyn scores for cochlear implant participants and their age at the date when speech sample was collected

Participant	Age	IPSyn score
PAM	4 years 0 months	93
NIK	5 years 4 months	83
GIA	5 years 7 months	83
FIN	5 years 8 months	76

Note. IPSyn, Index of Productive Syntax.

exhibited strong and widespread success in spoken English language skills. The PLS test is the most comprehensive of the tests that we administered, and both comprehension and production results indicate scores within a normal range for our native signing CI participants. Furthermore, they score above results predicted for oral-only children with CIs by Nicholas and Geers (2008).

For further comparison with oral-only CI children, EVT scores were reported for 15 children with CIs and no exposure to sign language by Geren and Snedeker (2009). Scores ranged from 75 to 131 (mean = 97.3, SD = 14.8), an overall high success rate that mirrored the age-target scores they report on the PPVT, which they administered to 21 children (a superset of the EVT participants), reporting a mean 97.3 (SD = 17.5). Their conclusion is that vocabulary constitutes one area of language development where children with CIs are, as a group, mostly scoring with their age-matched peers. A slightly different picture is seen in the large sample of children tested by Geers et al. (2009), who report only 58% of the 126 children with CIs that they tested scoring within 1 SD or higher of hearing age-mates. Their EVT mean standard scores ranged from 55 to 134 (mean = 90.67, SD = 18.98). Compared to these previous reports of EVT scores for children with CIs, our bilingual CI participants performed at monolingual English age target, and not significantly different from their hearing bilingual koda peers. In particular, they performed at (compared to Geren & Snedeker, 2009) or above (compared to Geers et al., 2009) expectations based on previous studies of children with CIs.

On the GFTA, a recent study by Spencer and Guo (2013) reports standard scores for children with CIs at varying ages postimplantation (12, 24, 36, and 48 months). In their study, of 14 children who were tested at 12 months postimplantation, only 50% performed within the typical range (standard score of at least 85) based on their chronological age. The group with the greatest number of children scoring within the typical range was the 20 children who have had their implant for the longest time (48 months), and therefore the most exposure to spoken language. In this group, 65% performed within the typical range. In our study, all four (100%) of the native signing children with CIs performed within the same normal range.

Similar results can be seen in the DIBELS Initial Sound Fluency test, where again CI participants performed very well. No direct comparisons exist for the DIBELS, but James et al. (2008) report scores from a comparable test of phonological awareness in typical children with CIs age 6–10. They also tested initial sound fluency (their "phoneme test") and found that even the group with early ages of implantation scored at a lower rate than hearing age-matched controls. Early implanted children had an accuracy rate of 57%, whereas hearing age-matched controls were at 89%. Late implanted children had an accuracy rate of 63% and age-matched controls had an accuracy rate of 97% (the late implanted group was older than the early implanted group). Thus, although typical children with CIs may lag behind hearing peers on phonological awareness, and specifically determining initial sounds of words, the five bimodal bilingual children with CIs in our study performed at the same high rate as their hearing bilingual peers.

Finally, scores on the IPSyn were calculated by Geers (2004) for 131 children aged 8–9 years old who had CIs. Of those children, 19 were implanted at age 2 and 24 were implanted at age 3, which corresponds to the approximate ages of implantation for the participants in our study. Of the children reported in Geers (2004) who were implanted by age 2, 53% had IPSyn scores greater than 75. Of those who were implanted by age 3, 48% had IPSyn scores greater than 75. Given the IPSyn scores in the population studied by Geers (2004), we might expect only about half of our CI participants to score greater than 75. However, as Table 5 shows, each of our four CI participants for which we were able to calculate an IPSyn had a score greater than 75, and thus none scored below what was considered to be in the less successful half of typical CI users of the same age.

In sum, results on a general test of English language (PLS), an expressive vocabulary measure (EVT), a test of articulation (GFTA), a test of early literacy skills (DIBELS), and a measure of syntactic complexity (IPSyn) all found our native signing CI participants behaving within a typical range for hearing peers. In some cases, this was established via standardized norms or age equivalences, and in four cases also by comparison with hearing bilingual peers (kodas) at the same testing fairs. We conclude from these results, first, that without a period of language deprivation before the implantation of the CI, children with CIs can develop spoken language skills appropriate for typically hearing children of the same age, and second, that sign language input does no harm to a deaf child's spoken language development after he/she receives a CI.

Similar hearing age-matched results on English language tests have been found for subgroups of children with CIs, such as those who are implanted extremely early (Geers et al., 2009; Geers, Strube, Tobey, & Moog, 2011). The participants in the current study were not implanted especially early, but they did have access to language from their parents from the day they were born. We take this confluence of factors to confirm the finding that early language input aids children's literacy and spoken language skills. Early implantation provides this linguistic input via spoken language, but early exposure to a natural sign language also provides exposure to linguistic structure through the visual modality. For caregivers who hesitate to commit to cochlear implantation at an early age for either social or medical factors, our research suggests that early exposure to a sign language provides access to abstract linguistic structure that also has the potential to provide benefits for later language learning. Teasing apart the contributions of early language (whatever the modality) from early auditory stimulation for spoken language learning requires more research beyond the small number of participants in the current study, but we believe that native signing children with CIs provide a crucial insight into the importance of access to abstract linguistic structure, whatever the modality.

There are difficulties in pursuing studies of this kind: approximately 95% of deaf children in the United States are born to hearing parents (Mitchell & Karchmer, 2004), leaving few deaf children of deaf parents. Of the few deaf children with deaf parents, communication between child and parent is natural, so many parents choose not to implant their child with a CI. Therefore, the population of native signing children with CIs is small, and consequently, our study has a small sample size of five children, of which only four were able to complete some tests. We also acknowledge that the self-selection process for inclusion in the study and the high socioeconomic status of our participants make the population advantaged in ways that not all children who receive CIs will be, even outside of the home language situation. Our aim here, then, is not to argue that all children with sign language input from birth will perform in line with the population discussed here. Rather, our goal is simply to illustrate that sign language input from birth does not impede spoken English language development on any measure of language tested.

Note that the results reported here show no bilingual disadvantage for either the children with CIs or the kodas. This is not to say that the children do not behave as typical bilinguals in terms of their language development and exhibit interactions between their languages. We report elsewhere on aspects of their language, which may reflect bilingualism effects. However, such effects are not frequent and do not appear on the standardized measures we used. These children do learn relatively early that different contexts are compatible with different types of language use, and our observation is that children in the 5- to 7-year-old age range show few bilingual effects in the English testing sessions.

Anecdotally, we report that the participants in our study with CIs are comfortable as bilinguals. They use sign language in relevant contexts and speech in other relevant contexts. Bilingualism in itself is easily accommodated in supportive family contexts. Note that some studies report spoken bilingual development for children with CIs. Robbins, Green, and Waltzman (2004) reported age equivalent standard scores in the first language, and steady improvement in the second language, for 12 deaf children with CIs having implants before the age of 3 years. They concluded (p. 646) that the children who are most proficient in two languages are "those whose parents spoke the second language at home, who had opportunities to use the language outside of home, and who had been wearing their CI for an extended time." Our participants experience strong home and community use of ASL and can be considered among those who are most likely to succeed as bilinguals.

Conclusion

Summarizing the data reported here, we examined the results of spoken English language measures, including vocabulary, articulation, syntax, general language skills, and phonological awareness, for five bimodal bilingual deaf children growing up as native signers and users of spoken English. In comparison to their hearing bimodal bilingual peers, and to norms for monolingual hearing age-mates, these children performed very well. Our primary conclusion is that early knowledge of a sign language does not prevent subsequent spoken language development using a CI and that it might well lead to greater success with such development.

Attitudes about cochlear implantation are changing, even among many in the Deaf community (see Paludneviciene & Leigh, 2011). For many children, a CI provides sufficient access to spoken language for it to be used in a range of communicative and educational settings. In addition, for many deaf children, knowledge of sign language is an asset that will be carried with them throughout their lives—along with knowledge of spoken language.

The decision whether to choose cochlear implantation, and whether to use sign language, spoken language, or some combination, is one that parents must make with as much solid evidence as possible about likely outcomes. In many cases, parents are dissuaded from using sign language with their children because of fears that it will detract from spoken language development. With Humphries et al. (2012), we see the issue as one which frequently unnecessarily diminishes the choices made available. The evidence reported here suggests that bimodal bilingualism should be considered as a serious option.

Note

1. The GFTA was not administered to PAM due to testing time constraints.

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Conflicts of Interest

No conflicts of interest were reported.

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