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Spanish and English Language Performance in Bilingual Children With Cochlear Implants

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Objectives: To document the factors that influence oral language performance in Spanish and English bilingual children with a cochlear implant.
Design: Using a repeated measures paradigm within a child, correlation and regression were used to analyze 4 factors that influence both Spanish and English receptive and expressive vocabulary, overall language skills, and articulation accuracy. The factors were age, duration of implantation, communication mode (total versus oral), and the amount of Spanish spoken at home.
Subjects: Twelve children between the ages of 49 and 106 months who had received a cochlear implant before 36 months. All subjects scored within the normal range of the nonverbal IQ Leiter test.
Main Outcome Measure: Spanish and English, receptive and expressive vocabulary, semantic and syntactic language skills, and articulation skills were measured using standardized tests, the Peabody Picture Vocabulary Test–IV, the Test de Vocabulario en Imagenes Peabody, the Expressive One Word Picture Vocabulary Test and Preschool Language Scale–IV, and the Goldman-Fristoe Test of Articulation–2. The amount of Spanish spoken at home was obtained via parental questionnaire.
Results: The raw scores of English language skills increased with increasing age and duration of implantation. Spanish skills were higher for higher Spanish spoken scores, and this effect was stronger when children were using oral communication mode. Lastly, oral communication mode had a positive effect on articulation accuracy.
Conclusion: Age, duration of implantation, the amount of home language use, and communication mode influenced the overall language skills for Spanish and English bilingual children. **Key Words:** Bilingual children—Cochlear Implants—English and Spanish oral language performance.

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Children with language impairment (LI) are at risk for substantially increased negative academic, social, and vocational outcomes and, hence, require early diagnosis and treatment (1). This issue has become even more important and challenging with the increasing diversity in culture, language, and educational backgrounds in the United States. Educators and professionals who care for children with special needs report an additional challenge in effectively serving children whose first language is not English (2).

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Despite the increased attention directed at this population in recent years, little is known about the most efficient treatment procedures for bilingual children with LI. The question is whether the treatment should occur in English or the home language (e.g., Spanish or Chinese). Recent studies in normal-hearing bilingual children with LI support the hypothesis that when children have language difficulties, they should be treated not only in English, that is, the language that will be used in the school setting, but also in their home language. When intervention happens without any long-term plan for increasing the individuals' opportunities to use their home language, the child may experience negative effects to their socio-emotional development (3). This is because a bilingual child without the home language will have limited interpersonal relationships with his/her family members. Using the home language not only supports emotional aspects but assists the child in developing self-identity. Thus, professionals should support home language competency (4).

Approximately 2 in 1,000 children in the United States are born with profound sensorineural hearing loss. As a result of progressive hearing loss in early childhood, by 4 years of age, 4 in a thousand children are potential candidates for a cochlear implant (CI). Children with a CI have great difficulties in learning a spoken language because of their limited linguistic input (5,6). The treatment is even more challenging for those children with a CI who grow up in a bilingual environment. Generally, both professionals and parents believe that learning 2 languages is more difficult than one, and thus, a child with a CI will find it even more challenging to learn both languages. However, this belief leads professionals to ignore the functional needs for both languages in bilingual children with LI.

The literature documenting the typical growth of 2 spoken languages in CI-recipient children is sparse, and as a result, there are few resources available that directly guide clinical decision making. Thus, debate continues over whether the treatment for CI-recipient children should follow that of normal-hearing bilingual children with LI (i.e., supporting the home language, as reported in previous studies) or should differ because these children not only experience 2 different language settings but also use a CI, in contrast to normal-hearing bilingual children. Recent research in language outcomes of bilingual children with a CI (7–9) supports their ability to learn both languages proficiently. These studies documented that language performance in bilingual children with a CI was comparable to that of monolingual children with a CI, and their performance increased with increasing time of CI use. However, there were several limitations in previous studies regarding factors (home language skills, the amount using home language, and influence of communication mode) important in investigating bilingual children (7–9). Thus, variables influencing speech and language outcome in bilingual children were more systematically controlled in this study.

This study has 4 main purposes: to determine whether child age and duration of implantation influenced English language competency in Spanish-English bilingual children, whether the amount of Spanish usage by family members influenced their Spanish, and whether communication mode (total versus oral) affected articulation test scores that represent their word level intelligibility.

Based on previous studies (10), we hypothesized that age and duration of implantation would have a positive effect on English language performance and that the amount of spoken home language would positively influence Spanish skills. We also hypothesized that those with oral communication mode would have better articulation accuracy scores.

MATERIALS AND METHODS

Subjects

Twelve congenitally and profoundly deaf children who received a Nucleus 22 or Nucleus 24 CI were recruited for this study. All participants had been diagnosed with bilateral sensorineural hearing loss before 24 months of age and received a CI before 36 months of age. All but 1 child had received a unilateral CI, and all children used electric-only stimulation. At the time of the study, the mean age of the children was 72.6 month old (standard deviation, 21.7), ranging from 49 to 106 months. The children were chosen for this study because they resided in dual-speaking language homes (Spanish and English). All children had consistently worn their implant(s) for at least 1 year before enrollment and throughout the study duration. All children received private speech-language therapy through the hospital either before or during the study. Children with known medical conditions likely to impede their development of auditory and spoken language were excluded (e.g., diagnoses of pervasive developmental delay). Thus, all children were within the normal range of nonverbal IQ as tested by the Leiter International Performance Scale–Revised (11). Four children used the total communication mode, and the other 8 used the oral communication mode. Demographic characteristics for subjects are shown in Table 1.

Procedure

All 12 children completed a battery of standardized assessments to determine their speech, language, hearing, and nonverbal IQ skills. The assessment battery was completed over 2 sessions for each language. Standardized language and speech assessments included the Preschool Language Scale–IV (PLS-IV) English and Spanish versions (12), which measured overall language performance; the Peabody Picture Vocabulary Test–IV (PPVT-IV) (13) for English receptive vocabulary, the Test de Vocabulario en Imagenes Peabody (TVIP) (14) for Spanish receptive vocabulary, the Expressive One Word Picture Vocabulary Test (EOWPVT) (15) for English and Spanish expressive vocabulary skills, and the Goldman-Fristoe Test of Articulation–2 (GFTA-2) (16) for articulation skills in English. For EOWPVT, if a child knew the concept of a word either in English or Spanish, it was considered that the child knew the word. Thus, 1 total raw score was used as a dependent measurement.

RESULTS

Table 2 shows the raw scores of all speech and language tests for the 12 children who were tested in each

TABLE 1. *Demographic characteristics of Spanish-English bilingual children*

Patient no.	Age (mo)	Age of CI implantation (mo)	Duration of implantation (mo)	Communication mode	Amount of Spanish spoken
1	49	12	37	Oral	3
2	51	14	37	Oral	3
3	54	18	36	Oral	3
4	57	22	35	Total	1
5	58	34	24	Total	3
6	60	12	48	Oral	1
7	66	21	45	Oral	1
8	76	30	46	Total	3
9	89	27	62	Oral	3
10	100	33	67	Oral	0
11	105	28	77	Oral	1
12	106	27	79	Total	1

Amount of Spanish Spoken (ASS) = If the child spoke Spanish with a communication partner, then a score of 1 was given. The communication partners were divided into 3 dimensions: mother, father, and siblings. Thus, the ASS score ranged from 0, in which the child does not speak Spanish with any of these 3 designated communication partners, to 3, in which the child uses Spanish with all family members.

TABLE 2. *Language scores in Spanish-English bilingual children*

Patient no.	PPVT	TVIP	EOWPVT	PLS-English	PLS-Spanish	GFTA
1	56	8	35	100	82	106
2	38	12	27	78	96	96
3	33	6	19	64	81	96
4	26	2	31	85	51	80
5	24	13	22	68	58	66
6	49	0	31	85	50	83
7	24	2	22	66	54	45
8	20	2	12	65	53	40
9	88	8	63	123	84	104
10	119	4	78	126	54	107
11	108	1	80	127	51	108
12	87	1	60	124	65	71

Individual scores on receptive and expressive vocabulary, overall language skills, and articulation accuracy on standardized tests.

PPVT indicates the Peabody Picture Vocabulary Test-IV (PPVT-IV) for English receptive vocabulary; TVIP, the Test de Vocabulario en Imagenes Peabody (TVIP) for Spanish receptive vocabulary; EOWPVT, the Expressive One Word Picture Vocabulary Test (EOWPVT) for expressive English and Spanish vocabulary skills; PLS-English, Preschool Language Scale-English (PLS-IV) for overall English skill and PLS-Spanish, Preschool Language Scale-Spanish (PLS-IV) for overall Spanish skills; GFTA, the Goldman-Fristoe Test of Articulation -2 (GFTA-2) for articulation accuracy on word level.

language. Additionally, the Spanish-speaking environment was analyzed by speaker: mother, father, and siblings. If the family members spoke with the target child in Spanish, they received a score of 1, and if they spoke English to the child, the score was 0. Thus, the highest score was 3, which represented a child embedded in a Spanish speaking environment (Amount of Spanish Spoken [ASS]) with all family members on a regular basis (Table 1). One child (no. 10) had ASS score of 0, which presents no one (mother, father, and siblings) spoke Spanish to the child on a regular basis. However, this child met our study inclusion and exclusion criteria, and the child was exposed to Spanish-English environment (e.g., the ethnicity was Hispanic, parents randomly speak Spanish, meeting grandparents and neighbors who speak Spanish).

There were 4 main findings. First, was the age and duration of implantation effects on English language scores. Additionally, it was the effect of the ASS scores on Spanish language scores. Lastly, the communication mode effect of articulation accuracy on word level was found.

First, the children's performance in English increased with increasing age, which was confirmed by the correlation shown in Table 3. Age was statistically significantly correlated with all English scores (d = 0.812, $p < 0.01$ for PPVT, $d = 0.828$, $p < 0.01$ for EOWPVT, and d = 0.784, p < 0.01 for PLS-English). The regressions shown in Table 4 were used to determine how much of the variance in language performance could be explained by age. The results showed that age statistically significantly predicted all English language scores. The full regression model accounted for 66.0% of the variance in PPVT, 68.5% for EOWPVT, and 61.5% for PLS-English.

Second, a strong correlation between duration of implantation and English language performance also was found. As Table 3 presents, correlation analysis confirmed that there was statistically significant positive relation between duration of implantation and English scores (d = 0.853, p < 0.01 for PPVT, d = 0.847, p < 0.01 for EOWPVT, and $d = 0.838$, $p < 0.01$ for PLS-English). The regressions (Table 4) were used to find the best model for predicting English language skills. The results showed that duration of implantation statistically significantly predicted all English language scores. The full regression model accounted for 72.8% of the variance in PPVT, 71.7% for EOWPVT, and 70.3% for PLS-English.

There was a strong correlation between age and duration of implantation (d = 0.941, p < 0.01). Thus, both variables were entered into the regression model to find which predictor best explained the English language skills. When using stepwise regression model, it was duration of implantation above and beyond age that best explained all English language scores.

Third, for Spanish skills, with descriptive analysis, children who had higher scores for the amount of Spanish spoken received higher TVIP and PLS-Spanish. Thus, the children using Spanish more at home had higher Spanish language scores. Additionally, the communication mode

TABLE 3. *Correlations among age, amount of Spanish spoken at home, communication mode, cochlear implant age (age at implantation), duration of implantation, and language scores*

	Age	ASS	CM	CI-age	DOI	PPVT	TVIP	EWOPVT	PLS-E	PLS-S	GFTA
Age	—	−0.07	0.05	0.64^a	0.94^a	0.81^a	−0.45	0.83^a	0.78^a	−0.32	0.13
ASS		—	0.37	0.03	−0.09	−0.30	−0.25	−0.34	−0.24	−0.41	−0.63^b
CM			—	0.48	−0.14	−0.35	−0.07	−0.27	−0.20	−0.37	−0.60^b
CI age				—	0.35	0.32	−0.01	0.38	0.28	−0.43	−0.21
DOI					—	0.85^a	−0.58	0.85^a	0.84^a	−0.20	0.26
PPVT						—	−0.22	0.98^a	0.95^a	−0.03	0.64^b
TVIP							–	−0.23	−0.23	0.68^a	0.24
EOWPVT								—	0.96^a	−0.10	0.61^b
PLS-E									—	−0.00	0.61^b
PLS-S										—	0.44

ASS indicates amount of Spanish spoken at home; CM, communication mode; CI-age, cochlear implant age; DOI, duration of implantation.
$^a p < 0.01$, $^b p < 0.05$.

TABLE 4. *Results of regression predicting language scores*

Step	R^2	Adjusted R^2	*p* level
PPVT			
Age	0.660	0.626	0.001
EOWPVT			
Age	0.685	0.654	0.001
PLS-E			
Age	0.615	0.577	0.003
PPVT			
Duration of implantation	0.728	0.701	0.000
EOWPVT			
Duration of implantation	0.717	0.689	0.001
PLS-E			
Duration of implantation	0.703	0.673	0.001
TVIP			
ASS	0.061	−0.033	0.438
PLS-S			
ASS	0.170	0.087	0.183
GFTA			
Communication mode	0.356	0.292	0.040

Based on the study hypothesis, age and duration of implantation were entered as variables for predicting English language skills, amount of Spanish spoken as a predictor for Spanish skills, and communication mode as a variable for predicting GFTA. *p* level refers to the significance levels for the predictor variable entered into the regression.

drove this effect more strongly. If the family used oral communication mode within the Spanish-speaking environment, then the child's Spanish skills were strong. This was observed with children nos. 5 and 8 having a language score with family members of 3 but using total communication mode had a low Spanish score, whereas other children using oral communication mode had a high Spanish score, with the same score of 3. However, with correlation and regression analysis, we could not observe this effect. Interestingly, the amount of home language spoken was significantly correlated with GFTA (d = -0.63, $p < 0.05$) with the full regression model accounted for 39.8% of the variance. Thus, if the child had higher ASS scores, using more Spanish at home, then the child's GFTA score was lower.

Lastly, the influence of communication mode on GFTA was examined. The speech sound accuracy on word level was statistically significantly correlated with communication mode (d = -0.571, $p < 0.05$). The regression model accounted for 35.6% of the variance in GFTA. If the child was using oral communication mode, then the child's GFTA was higher, indicating a more accurate articulation of a target word.

DISCUSSION

This study was designed to examine whether age and duration of implantation influence English skills, whether the amount of home language spoken influences Spanish skills, and whether the communication mode influences English articulation accuracy. Children were tested on a wide range of Spanish and English language standardized tests. Descriptive analysis with correlation and regression models was used to analyze the data.

The results showed that the English receptive and expressive scores and overall English semantic and syntactic scores of bilingual children with a CI increased with increasing age. These results were found in previous studies in which bilingual children with CI showed outstanding performance in English and were comparable to monolingual peers with a CI (7–9). These results are in line with other typical bilingual children with normal hearing (10). Thus, we learned that English skills increase in this population as they get older. Despite this summary comment, 2 children were outliers when observed with descriptive statistics. The youngest 2 children had high language skills in both English and Spanish. The results were not statistically significant, but these 2 children had the youngest age when receiving their CI: 12 and 14 months. Thus, it is assumed that young bilingual children who received their CI earlier had a better language outcome as documented from many other studies in monolingual children with a CI (17–21).

Another important factor that contributed to English language performance was duration of implantation. This variable was stronger than the age factor confirmed by the stepwise regression model when predicting English language skills. Both age at implantation and duration of implantation are well-known variables that provide age-appropriate achievement of a spoken language (9,18,19, 21). The reason there was no noticeable correlation between age at implantation and English scores may be that all of our children were controlled for this factor as having implantation before 36 months. However, our findings suggest that the longer the duration of implantation, the better the English outcome.

Contrary to our hypothesis, the amount of Spanish spoken had no statistically significant effect on the Spanish skills. However, the amount of spoken home language along with communication mode affected the Spanish skills. Two children with total communication mode with the same score of the amount of Spanish spoken had different results from children who used the oral communication mode. Based on our descriptive data results, the oral communication mode had a positive influence on Spanish skills under the same condition of the amount of Spanish spoken.

The study findings also suggested that communication mode has a positive influence on speech accuracy on word level. The children using the oral communication mode had better speech sound accuracy on the English word level.

Variables such as duration of implantation and communication mode (total versus oral) are known to influence the outcome of speech and language skills (17–21). Additionally, over the course of exposure to English, a child's dominant language tends to become English (10) so that the amount of home language spoken will help to maintain their home language. However, it has not been determined whether these same factors have a similar effect on bilingual children with a CI. Therefore, the results from this study supported the idea that 4 common factors—age, duration of implantation, the amount of home language spoken, and communication mode—that are known to be crucial for language outcome of typical monolingual children with CI also are influential for children with a CI among Spanish-English bilingual children.

This study adds to the literature on oral language performance for bilingual children with CI. In previous studies (7–9), bilingual children were variable in the usage of their home language (e.g., Yiddish, Hebrew, and Armenian) and may not represent sequential bilingual families whose home language has low status in the United States (3). In previous studies, all parents were fluent in English, although it was not their native language. In this study, the definition of first language differs from that in previous studies. The definition of first language used in this study is the mothers' native language, Spanish, and the second language is the school or society language, English. This type of family represents the majority of bilingual speakers living in the United States with which English is not a fluent language and thus the input of English may be limited. Thus, variables (language used among children, parents, and siblings) known to have the potential to influence bilingual children's language abilities were systematically controlled in this study.

Additionally, as previous studies measured the performance of languages other than English using a rating scale based on observation, limited information was provided. In this study, we assessed language performance in a more complete way using 6 different standardized tests in both languages. Receptive and expressive vocabulary size, overall language performance assessing semantic and syntactic skills, and articulation accuracy were measured. These measures provided a broader and more complete picture of the language skills in bilingual children with a CI, both in Spanish and in English. However, standardized language measurements are known to be biased for bilingual children who are raised in the United States (22–25). Thus, we used the raw scores of each language performance on all language tests.

This study examined broad perspectives of both Spanish and English skills and was designed with strict controls over the participating children's age of CI implantation and duration of CI usage. Additionally, the amount of home language spoken was systematically obtained based on the language spoken by parents or siblings. However, 1 study limitation arose because the actual amount of time spoken with parents or siblings was not counted into the factor. There may be families in which the child interacts more with mothers in one language but more with the siblings in another language. Additionally, there might be a quality difference, which drives the child's language outcome based on the input method of the target language. However, even with a simplistic measurement, our method of analyzing the amount of Spanish spoken revealed a trend in which Spanish skills improved as the child spoke the language more often. Thus, future study using more systematic documentation to examine the quantity and quality of the language spoken with the parent and siblings is warranted.

Another study limitation was the uncertainty in the distribution of the English and Spanish expressive vocabulary for EOWPVT because the measurement counted as accurate if the child knew the word either in Spanish or in English. For EOWPVT, the age effect was only evident with English skills. Thus, it is assumed that a proportion of English vocabulary must have taken over Spanish. However, the accuracy of future analysis will be increased by examining whether there is any difference in distribution of each language within EOWPVT scores.

In summary, using various metrics for assessment of speech and language skills, Spanish-English bilingual children with a CI were examined. Findings from this study were as follows: English language skills increased with age and duration of implantation; Spanish skills were higher among children exposed to more Spanish home environment; and oral communication mode had a positive effect on articulation ability. Thus, our results confirmed that English language performance increases with age and especially with duration of implantation (even in Spanish-speaking home settings) and more intense (more frequent and oral only communication) language exposure. Knowledge of the factors that influence overall language skills in bilingual children with a CI is of practical importance to parents, implant centers, and early intervention and special education programs from counseling, therapeutic, and curriculum perspectives. The new knowledge obtained from this study will increase the understanding of bilingual children with a CI and their parents of their expected language outcome and of the most suitable treatment to optimize their long-term language growth. In addition, medical and educational professionals who deal with such children will have increased understanding of the expected language growth and greater confidence in how to better serve bilingual children with a CI. For future study, it is needed to examine the relationship between the amount of each language usage and its competency using qualitative analysis. Additionally, further studies will have to develop deeper investigation of unique and common factors for bilingual children compared with monolingual children that are important for language outcome to optimize their competency. Lastly, a longitudinal study examining children with CI along with children with normal hearing would give us a complete picture of how overall language performance dynamically change overtime in bilingual children with CI.

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