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Intervention and Outcomes of Children in Different Types of Listening and Spoken Language Programs

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Abstract: This study explores the impact of the type and dosage of listening and spoken language (LSL) services on speech and language outcomes in children with cochlear implants or hearing aids in two LSL programs. Identical demographic variables were collected across the two programs for use in the statistical analyses. Speech and language outcomes were examined at ages 3 and 5 using standardized test measures. At age 3, significant differences in LSL outcomes existed between programs for children using cochlear implants but not for children using binaural hearing aids. However, at age 5, outcomes were similar between the different LSL programs for children with hearing aids and cochlear implants. Total hours of LSL services do not serve as a predictor of LSL outcomes at 5 years of age. However, early identification of hearing loss, early amplification, and early enrollment in an LSL program were highly influential factors affecting LSL outcomes at 3 and 5 years of age. Non-verbal IQ and maternal education levels also influence LSL outcomes. Children with earlier access to hearing technology and LSL intervention may need fewer hours of LSL services to achieve age-appropriate LSL outcomes. Overall, both of these LSL programs supported age-appropriate speech and language outcomes by age 5.

Keywords: Children; Hearing Loss; Cochlear Implants; Hearing Aids; Early Intervention; Listening and Spoken Language

Acronyms: CI = cochlear implant; DHH = deaf and hard of hearing; LME = linear mixed effect; LSL = Listening and Spoken Language; LSLS = Listening and Spoken Language Specialists; PCA = Principle Components Analysis; SES = socio-economic status; WNL = within normal limits

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For children who are deaf or hard of hearing (DHH), listening and spoken language (LSL) services focus on intelligible speech production, auditory comprehension, and receptive and expressive language abilities. Several factors are known to influence LSL outcomes of children who are DHH including age at identification of hearing loss, ages of hearing aid fitting and cochlear implantation, the child's non-verbal IQ, and caregiver socioeconomic status (SES) and education level (Ching et al., 2018; Geers et al., 2011; Leigh et al., 2016; Niparko et al., 2010). LSL intervention is critical to listening and spoken language outcomes; however, only a few studies have explored the impact of LSL intervention dose (i.e., frequency of intervention) on the LSL outcomes of children who are DHH.

Geers and colleagues (2019) evaluated the effect of LSL intervention dosage on LSL outcomes at 4–6 and 8–14 years of age for 50 children who were DHH and received services prior to 36 months of age. Between birth to 18 months, children received one-hour home visits from a LSL provider at least twice a month and a one-hour LSL session at the Moog Center for Deaf Education once a month. The sessions were primarily parent-centered with a focus on coaching the caregiver to facilitate the child's LSL development. Children older than 18 months attended a LSL class at the Moog Center for Deaf Education for 3.5 hours per day from 2 to 5 days a week depending on age. This LSL class included a one-hour individual LSL therapy session with the child, 2.5 hours of LSL group experiences, and weekly, 30-minute individual sessions with the parent and child. Individual LSL services hours ranged from 0 to 279, and group LSL services hours ranged from 0 to 482. Over half the children achieved LSL outcomes within normal limits by 4 to 6 years of age, and over 70% achieved normal LSL outcomes by 8 to 14 years of age. Children who received more LSL hours between 0 to 36 months achieved higher LSL outcomes at 4 to 6 and 8 to 14 years of age when compared to children with fewer LSL hours, even after accounting for age at hearing aid fitting and intervention, speech perception ability, and non-verbal IQ. In addition, children with poorer speech perception scores were more likely to benefit from greater dosage of LSL services when compared to the LSL peers with better speech perception abilities.

Previous work by Scott and colleagues (2019) examined longitudinal growth of phonological awareness, letter-word identification, and expressive vocabulary skills in 56 children between the ages of 3 and 5 who were DHH. All children in the study were enrolled in DHH preschools and instructed by teachers of the deaf. Results showed significant improvements in literacy and vocabulary skills during the school year but not during summer break. For students with access to auditory cues, significant growth in phonological awareness was only observed during the school year as well. The results support intensive early education for children who are DHH and suggest additional schooling during the summer might be indicated.

In an earlier study, Moog and Geers (2010) examined the effect of age of LSL services and type of intervention on receptive and expressive language, vocabulary, and verbal reasoning at 5 to 6 years of age for 141 children with cochlear implants. Better LSL outcomes were found for earlier-implanted children (i.e., < 24 months) and those enrolled in weekly parent-infant LSL intervention by one year of age. In addition, children who were enrolled in LSL services for at least nine hours a week by two years of age had better LSL outcomes than those enrolled at a later age. Across LSL outcomes, 44% to 65% of children had standard scores within normal limits (WNL is defined as less than or equal to one SD from normative mean) by 5 to 6 years. Moreover, 71% of the children who attended a LSL education program from two to four years of age achieved outcomes WNL when compared to 41% who did not attend a LSL program until 3 years of age. Overall, better outcomes were reported for children with an earlier age at implant and earlier and more frequent LSL services.

In contrast, a recent study by Chu and colleagues (2019) found an inverse relationship between LSL intervention dosage and expressive language outcomes. In their study, they examined the effect of LSL services dosage on LSL outcomes of 42 children who used cochlear implants and received intervention up to 7 years of age. The average age at implantation was 1.9 years, and 14 children received implants before 12 months of age. In the study cohort, some children received home-based LSL services, whereas others received center-based services with individual dosages determined using a family-centered, evidenced-based approach. The results indicated that children who received fewer LSL intervention hours were more likely to receive a cochlear implant at an earlier age, likely because earlier-implanted children were achieving better outcomes than later-implanted children. In addition, caregivers of children who were achieving age-appropriate LSL skills attended fewer LSL sessions. Overall, the authors report better LSL outcomes for earlier-implanted children (i.e., ≤ 12 months) and the need for fewer LSL hours for earlier-implanted children.

Given the mixed findings and the limited number of studies exploring the dosage and type of LSL services on the outcomes of children who are DHH, additional research is warranted. The current study explores the type and dosage of LSL services received by children from two listening and spoken language programs with different approaches to intervention. The objectives of this study are to: (a) summarize LSL outcomes of the children participating in the two LSL programs, and (b) explore the relationship between type and dosage of LSL services and outcomes measured at 3 and 5 years of age.

Method

Study participants included children who received services from two LSL programs: the Moog Center for Deaf Education and Hearts for Hearing.

Moog Center for Deaf Education Description

The Moog Center for Deaf Education is an independent, not-for-profit audiology and LSL program that provides pediatric audiology and LSL services in an educational setting to children who are deaf or hard of hearing from birth to early elementary years and their families. Pediatric audiologists complete diagnostic assessments (e.g., auditory brainstem response testing, otoacoustic emissions, middle ear measurements, behavioral audiologic assessment) to evaluate auditory function of children who have been identified with hearing loss or referred to the Moog Center for concerns regarding auditory function and/or speech and language delay. Hearing aids are fitted as soon as possible following identification of hearing loss and referral. Recommendation for cochlear implantation is made for children who have severe to profound hearing loss and whose needs are not adequately supported by hearing aid use.

For children who are birth to 18 months of age, the Moog Center provides one-hour home visits or online (tele-intervention) sessions led by a certified teacher of the deaf at least once a month and a center-based session once a month. These sessions include the provision of information to parents/caregivers, coaching of parents/caregivers to facilitate their children's individual speech, listening, and spoken language outcomes, and engagement in activities focused on LSL strategies designed to support listening and spoken language development in their children's daily lives. For children who are 18 months to 3 years of age, the Moog Center provides a center-based LSL program in addition to their home visits or tele-intervention sessions, as described above. Children may attend the center-based program 2 to 5 days a week depending on age, developmental factors, and family factors. The center-based program includes 60-minute individual sessions which focus on the development of speech, language, and listening skills, and 2.5-hour group sessions which focus on early cognitive, motor, and social skills development. For children who are 3 to 5 years of age, the Moog Center offers a Preschool program. Services in the Preschool are provided by certified teachers of the deaf and speech-language pathologists, all of whom are Listening and Spoken Language Specialists (LSLS) or seeking certification, along with early childhood educators. Children in the Preschool may receive 3 hours of individualized LSL services and 2 hours of small-group instruction daily. Preschool sessions focus on the development of individualized speech, language, and listening skills, as well as math, early literacy, and social skills. In addition, optional weekly parent/caregiver coaching, support group, and parent educational sessions are offered.

Hearts for Hearing Description

Hearts for Hearing is an independent, not-for-profit audiology and LSL program that provides pediatric audiology and LSL therapy for children with hearing loss. Pediatric audiologists complete diagnostic assessments (e.g., auditory brainstem response testing, otoacoustic emissions, middle ear measurements, behavioral audiologic assessment) to evaluate auditory function of children who do not pass newborn hearing screening or are referred for concerns regarding auditory function and/or speech and language delay. In line with the center's mission, hearing aids are fitted within days of the diagnosis of hearing loss, and cochlear implants are provided for children who have severe to profound hearing loss and whose needs are not adequately supported by hearing aid use.

Hearts for Hearing provides weekly or monthly, one-hour LSL therapy sessions led by an LSL clinician (who is either a LSLS or pursuing certification) in person or via tele-intervention sessions. Sessions include information for parents, parent coaching, and activities to facilitate LSL development. A monthly, one-hour, parent-infant group, led by two LSL specialists and a pediatric audiologist, is provided for children birth to 24 months of age. The group provides information on hearing loss and LSL development as well as peer support for caregivers of infants with hearing loss. A two-hour, parent-toddler class, led by a LSLS and an early childhood educator, is provided for children who are 2 to 3 years old. This class includes activities to promote and enrich the child's listening and spoken language. Finally, a 3-year-old class, team-taught by an early childhood educator and a speech-language pathologist pursuing LSLS certification, is offered for children ages 3 to 4 years. The class of 8 to 10 children is offered twice a week for 2.5 hours a day. Most children attend the class for up to one year, but children may participate longer if they have language delays affecting potential success in a mainstream preschool setting.

Study Participants

The enrollment databases and clinical records were reviewed at the Moog Center for Deaf Education and Hearts for Hearing to identify children who had received services at each program. Children who met the following criteria were included in this study.

Inclusion Criteria

- Bilateral hearing loss with a pure tone average (mean air conduction thresholds 500, 1000, and 2000 Hz) poorer than 25 dB HL in the better ear.
- Children with congenital hearing loss or perilinguistic hearing loss identified by 36 months of age.
- Children who received services at one of the two programs and for whom results are available for standardized assessments of LSL aptitude at 3 and/or 5 years of age.
- Children who regularly participated in the LSL programs of the respective study sites as defined by an attendance rate of at least 50% (i.e., attended at least 50% of scheduled appointments).
- Children who use air conduction hearing aids, bone conduction devices, and/or cochlear implants.
- Children who communicate primarily via listening and spoken language and who are native speakers of American English.

Exclusion Criteria

- Children clinically diagnosed with neurocognitive disabilities or other disabilities that would adversely impact LSL development (e.g., autism spectrum disorder, apraxia, dysarthria, selective mutism, etc.).
- English spoken as a second language.
- Non-verbal IQ standard score poorer than 70.
- Unilateral hearing loss.

A total of 218 children met the listed inclusion criteria, with 111 children from the Moog Center, 47 of whom used binaural hearing aids and 64 who used cochlear implants. From Hearts for Hearing, 107 children were included, 61 of whom used binaural hearing aids and 46 who used cochlear implants. Across sites, the cohort of children with cochlear implants included 19 children with a bimodal approach (hearing aid + cochlear implant), 5 children using a unilateral cochlear implant, and 86 children using bilateral cochlear implants.

The study participants' scores from standardized measures of listening and spoken language aptitude administered at 3 and 5 years of age were obtained from their personal files at the study programs and from the OPTION Schools, Inc. Listening and Spoken Language Data Repository (LSL-DR; i.e., REDCap database; Bradham et al., 2018). The Western Institutional Review Board provided regulatory approval for this study. The following standardized measures were used to evaluate the LSL outcomes of the children in this study.

Language Assessment

- Clinical Evaluation of Language Fundamentals Preschool-2 (CELF P-2; Semel et al., 2004).
    - The First Edition of this assessment was used in some early data.
- Clinical Evaluation of Language Fundamentals–Fifth Edition (CELF-5; Wiig et al., 2013).
    - The Fourth Edition of this assessment was used in some early data.
- Preschool Language Scales–Fifth Edition (PLS-5; Zimmerman et al., 2011).

Vocabulary Assessment

- Expressive Vocabulary Test–Third Edition (EVT-3; Williams, 2018).
    - The First and Second Editions of this assessment were used in some early data.
- Expressive One-Word Picture Vocabulary Test–Fourth Edition (EOWPVT-4; Brownell, 2010a).
- Receptive One-Word Picture Vocabulary Test–Fourth Edition (ROWPVT-4; Brownell, 2010b).
- Peabody Picture Vocabulary Test–Fourth Edition (PPVT-4; Dunn & Dunn, 2007).
    - The Third Edition of this assessment was used in some early data.

Speech Production/Articulation

- Goldman-Fristoe Test of Articulation 3 (GFTA-3; Goldman & Fristoe, 2015).
    - The Second Edition of this assessment was used in some early data.
- Clinical Assessment of Articulation and Phonology–Second Edition (CAAP-2; Secord & Donohue, 2013).

Of note, the children who were evaluated at 5 years of age also were evaluated at 3 years of age. However, not all the children who were evaluated at 3 years of age were evaluated at 5 years of age (i.e., some children were no longer enrolled in intervention at 5 years of age, and as a result, were not evaluated).

For each of the standardized vocabulary and language measures, test items increase in difficulty throughout the test, and assessment continues until the child encounters a ceiling score determined by a specified sequence of incorrect responses. Each measure yields a standard score based on normative data obtained from a group of age-matched, typically-developing peers with normal hearing. The group mean obtained from the normative data is set to 100, and each standard deviation (SD) from that mean is represented by +/-15 points (i.e., 85 and 115 are +/- 1 SD from the mean, respectively). For additional information pertaining to a description of the measures used to evaluate LSL outcomes in this study, the reader is referred to the citations associated with each test listed above.

The children's non-verbal intelligence quotients (IQs) were evaluated with the Central Institute for the Deaf Preschool Performance Scale (CID-PPS; Geers & Lane, 1984), Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990), Kaufman Brief Intelligence Test–2nd Edition (KBIT-2; Kaufman & Kaufman, 2004), Primary Test of Nonverbal Intelligence (PTONI; Ehrler & McGhee, 2008), Weschler Intelligence Scale for Children–5th Edition (WISC-V; Wechsler, 2014), Weschler Preschool and Primary Scale of Intelligence–3rd Edition (WPPSI-III; Wechsler, 2002), and Weschler Preschool and Primary Scale of Intelligence–4th Edition (WPPSI-IV; Wechsler, 2012). As with the standardized measures of LSL outcomes, the non-verbal IQ assessments administered in this study were norm-referenced with a mean of 100 and +/-1 SD corresponding to 15 points.

Statistical Analysis

Similar to a previous study of LSL outcomes (e.g., Ching et al., 2018), separate statistical analyses were conducted for children who used binaural hearing aids and those who used cochlear implants for at least one ear. Principal Components Analysis (PCA) was used to compute eigenvalues for the two different test measures and confirmed the CELF and PLS loaded onto the same expressive language factor (only the first principal component exceeded 1), ensuring equivalence of the different measures. To reduce Type I errors, PCA was also used to create a composite score for expressive language (PLS/CELF, EOWVT) outcomes (Davidson et al., 2019; Strube, 2003; Tomblin et al., 2015). The expressive language composite score had a mean of 100 and a standard deviation of 15. Similar to the expressive language measures, PCA confirmed scores from the PLS/CELF and PPVT loaded onto the same factor, and a composite receptive language score was computed for each child (mean 100, standard deviation of 15).

Separate linear mixed-effect (LME) regression analyses were performed to examine expressive and receptive language, core language, and articulation outcomes in (a) children with cochlear implants at 3 and 5 years of age, and (b) children with hearing aids at 3 and 5 years of age. In the cochlear implant (CI) analyses, C*ochlear Implant Recipient* was treated as a random effect to control for baseline differences across pediatric patients. *Mother's Education Level* (high school, some college, college); *Nonverbal IQ; Age at Hearing Aid* (months); and *Age at 1st CI* (months) were included in the models to control for important demographic and audiological characteristics. To assess the effects of LSL intervention on language outcomes, *LSL Program* (Moog Center vs Hearts for Hearing); *Age of Enrollment in LSL Program* (months*)*; *Intervention Hours from 0–3 Years of Age* (when applicable)*; Intervention Hours from 0–5 Years of Age* (when applicable) and two and three-way interactions between intervention variables were also included in the models as fixed effects.

In the hearing aid analyses, *LSL Participant* was treated as a random effect to control for baseline differences across pediatric patients. *Mother's Education Level* (high school, some college, college); *Nonverbal IQ; Age at Hearing*

Aid (months); and *Degree of Hearing Loss* were included in the models to control for important demographic and audiological characteristics. To assess the effects of LSL intervention on language outcomes, *Program* (Moog Center vs Hearts for Hearing); *Age of Enrollment in LSL program* (months); *Intervention Hours from 0–3 Years of Age* (when applicable); *Intervention Hours from 0–5* (when applicable) and interactions between intervention variables were also included in the models as fixed effects. For the cochlear implant and hearing aid analyses, full models were run with all fixed effects and interactions. If the interactions were not significant, they were removed from the model. Fixed effects were assessed using a significance α = 0.05. Regression diagnostics were performed for each analysis and all assumptions were met.

Results

Comparison Demographic Characteristics

The demographics for the study participants are provided in Table 1. Items in bolded font indicate a statistically significant difference in demographic variables between children from the Moog Center and Hearts for Hearing.

As shown in Table 1, the Moog Center group contained a greater percentage of children with severe to profound hearing loss who were using hearing aids. Additionally, children using cochlear implants were fitted with hearing aids at significantly earlier ages at Hearts for Hearing.

A summary of the age of enrollment and hours of LSL services received by the children in the Moog Center and Hearts for Hearing programs is provided in Table 2. Items in bolded font indicate statistically significant differences in the LSL services received by children from the Moog Center and Hearts for Hearing. As shown in Table 2, for cochlear implant recipients, children enrolled in the LSL program started earlier at Hearts for Hearing relative to their counterparts at the Moog Center. There was no difference in the age of enrollment at Hearts for Hearing and the Moog Center for children who were using binaural hearing aids. Moreover, children at the Moog Center received significantly more LSL hours from birth to 3 years of age and from birth through 5 years of age than their Hearts for Hearing counterparts, which was true for both those with binaural hearing aids and those who received cochlear implants.

Table 1

Demographic Information for the Study Participants with Hearing Aids (HA) and Cochlear Implants (CI)

Intervention	Hearing Aids		Cochlear Implants	
Treatment Group	Hearts for Hearing (n = 61)	Moog Center (n = 47)	Hearts for Hearing (n = 46)	Moog Center (n = 64)
Maternal Education				
High school	23.3%	2.9%	17.4%	15.0%
Some College	11.7%	34.3%	10.9%	20.0%
College	65.0%	62.8%	71.7%	65.0%
SES				
<$25,000	0%	4.5%	0%	6.3%
$25,000–$49,999	21.3%	18.2%	15.2%	18.8%
$50,000–$74,999	31.1%	9.1%	26.1%	15.6%
$75,000–$99,999	23%	18.2%	23.9%	15.6%
$100,000+	24.6%	50.0%	34.8%	43.8%
Mean Nonverbal IQ	106.6 (13.3)	109.6 (13.1)	106.2 (10.3)	110.4 (11.5)
Mean Age HA (months)	10.7 (12.9)	10.3 (10.2)	**6.2 (8.3)**	**8.9 (7.6)**
Mean Age 1st CI (months)	.	.	22.0 (16.5)	22.9 (16.5)
Degree of Hearing Loss			.	.
Mild	24.6%	8.5%	.	.
Moderate	41.0%	19.1%	.	.
Moderate–Severe	29.5%	14.9%	.	.
Severe–Profound	4.9%	57.5%		

Note. IQ = intelligence quotient; SES = socioeconomic status. Numbers in bold represent significant program differences according to *t*-test ($p < 0.05$). Numbers in parentheses represent standard deviation.

Table 2
Summary of Early Intervention Ages and Hours by Program

Intervention	Hearing Aids		Cochlear Implants	
	Hearts for Hearing	Moog Center	Hearts for Hearing	Moog Center
Mean Age of Enrollment (Months)	12.9 (14.0)	13.5 (12.7)	7.0 (8.6)	20.0 (13.9)
Mean Total Hours Per Child from 0–3 Years	49.6 (39.5)	364.2 (198.6)	75.9 (49.2)	356.0 (245.8)
Mean Total Hours Per Child from 0–5 Years	103.4 (76.7)	1350.9 (532.5)	163.9 (105.1)	1547.9 (529.7)

Note. Numbers in bold represent significant program differences according to *t*-test ($p < 0.05$). Numbers in parentheses represent standard deviation.

Children Using Cochlear Implants

The following results are for children using cochlear implants. LME regression analyses were used to analyze how LSL intervention factors contributed to expressive language scores of children at Hearts for Hearing and the Moog Center when controlling for important demographic and audiological variables for children using cochlear implants. Table 3 shows the regression weights and the associated significance values for predicting expressive language outcomes at 3 years and 5 years of age. At 3 years of age, earlier age of hearing aid fit, higher maternal education, and greater amount of LSL intervention hours were associated with a significant increase in expressive language outcomes (Table 3). At age 3, children receiving intervention at the Moog Center were predicted to have expressive language scores 12.7 points lower than children at Hearts for Hearing. However, at 5 years of age, none of the demographic, program, or intervention factors were predictive of expressive language outcomes, meaning children at both programs were predicted to have similar expressive language outcomes at age 5. Figure 1 shows the distribution of the expressive language scores for the Moog Center and Hearts for Hearing groups at 3 and 5 years of age for children using cochlear implants. Between programs, expressive language outcomes were significantly different at age 3, but not at age 5.

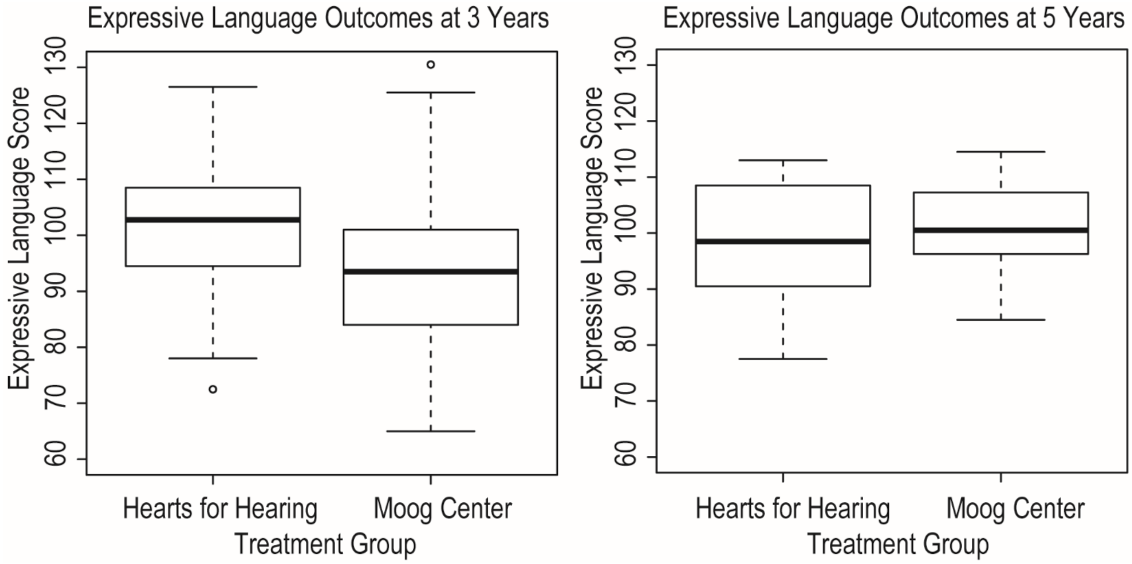
Table 3
Regression Analysis Results of Cochlear Implant (CI) Expressive Language Outcomes at 3 and 5 Years of Age

Expressive Language	3 years of age ($R^2 = 0.37$)			5 years of age ($R^2 = 0.37$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	85.9	4216.7	< .0001	70.8	4075.2	< .0001
Maternal Education		4.44	.02		0.22	.81
High School	-10.9			-6.24		
Some college	-12.5			-4.62		
College graduate	0			0		
Nonverbal IQ	0.19	1.6	.21	0.32	2.45	.13
Age HA (months)	-0.5	9.4	.003	-0.3	2.9	.1
Age 1st CI (months)	0.02	0.04	.84	0.02	0.03	.86
Treatment Group		3.7	.06		0.04	.84
Hearts for Hearing	0			0		
Moog Center	-12.7			4.61		
Age enrollment LSL	-0.03	3.7	.06	-0.27	2.2	.15
LSL Intervention Hours	0.02	4.5	.04	-0.001	.07	0.79

Note. HA = hearing aid; IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 1

Expressive Language Scores for Children with Cochlear Implants at 3 and 5 Years Old

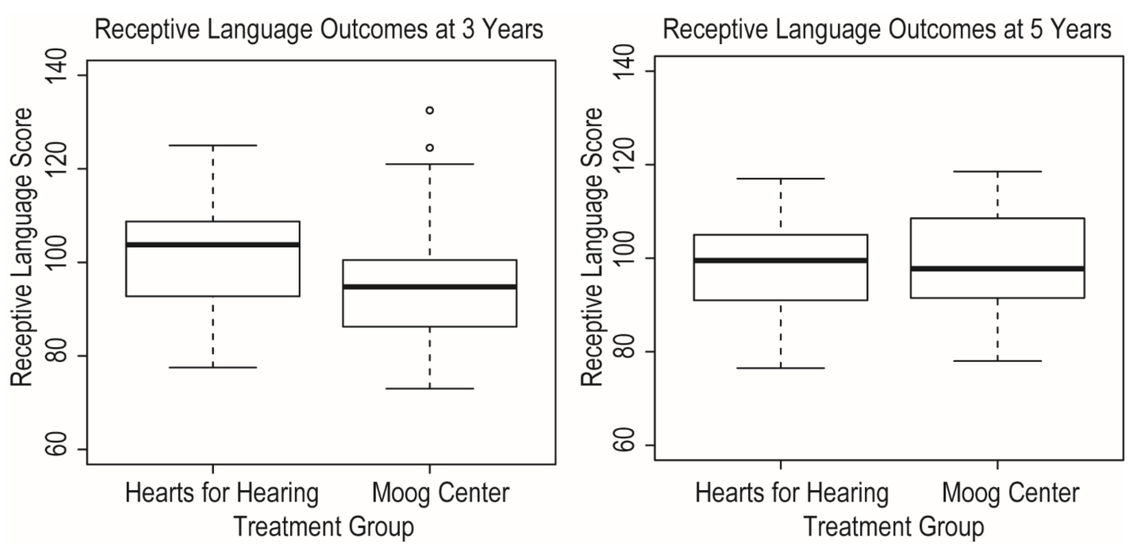


Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers, denoted as circles, are values greater than 1.5 times the interquartile range.

LME regression analyses were used to analyze how LSL intervention factors contributed to receptive language scores in children at Hearts for Hearing and the Moog Center. The regression weights and associated significance values for predicting receptive language outcomes at 3 years and 5 years of age for children using cochlear implants are displayed in Table 4. Higher maternal education years, higher nonverbal IQ, and earlier age of hearing aid fit were significant predictors of receptive language outcomes at 3 years of age (Table 4). Earlier age of enrollment in LSL intervention, and higher number of LSL intervention hours were associated with better receptive language outcomes at age 3, but these effects just failed to reach significance ($p = 0.06$). Similar to expressive language outcomes, none of the factors that were significant at 3 years of age were significant predictors of receptive language outcomes at 5 years of age. Figure 2 shows the distribution of the receptive language scores for the Moog Center and Hearts for Hearing groups at 3 and 5 years of age for children with cochlear implants. Between programs, receptive language outcomes were not significantly different at age 3 or age 5.

Figure 2

Receptive Language Scores for Children with Cochlear Implants at 3 and 5 Years Old



Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers, denoted as circles, are values greater than 1.5 times the interquartile range.

Table 4
Regression Analysis Results of Cochlear Implant (CI) Receptive Language Outcomes at 3 and 5 Years of Age

Receptive Language	3 years of age (R^2 = 0.43)			5 years of age (R^2 = 0.09)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	81.02	6672.7	< .0001	94.03	3279.2	< .0001
Maternal Education		9.3	.0003		0.54	.59
High School	-10.8			-4.2		
Some college	-12.6			-0.36		
College graduate	0			0		
Nonverbal IQ	0.26	4.7	.04	0.08	0.19	.67
Age HA (months)	-0.43	7.13	.009	-0.2	0.38	.54
Age 1st CI (months)	-0.09	2.4	.13	-0.04	0.07	.79
Treatment Group		3.2	.08		0.22	.64
Hearts for Hearing	0			0		
Moog Center	-8.9			-9.6		
Age enrollment LSL	-0.06	3.7	.06	0.04	0.07	.8
LSL Intervention Hours	0.02	3.5	.06	0.005	0.8	.38

Note. HA = hearing aid; IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

LME regression analyses were used to analyze how LSL intervention factors contributed to core language outcomes in children at Hearts for Hearing and the Moog Center at age 3 and age 5 for children using cochlear implants. Table 5 shows the regression weights and the associated significance values for predicting core language outcomes at 3 years and 5 years of age. Higher maternal education years and earlier age of hearing aid fit were significant predictors of language core outcomes at 3 years of age. Children receiving intervention at Hearts for Hearing were predicted to have language core scores 15.3 points higher than children at the Moog Center at age 3. However, the program was not a significant predictor of language core scores at age 5, suggesting children at the Moog Center and Hearts for Hearing performed similarly at age 5. Figure 3 shows the distribution of the core language scores for the Moog Center and Hearts for Hearing groups at 3 and 5 years of age for children using cochlear implants. Between programs, core language outcomes were significantly different at age 3, but not at age 5.

Table 6 displays the regression coefficients and associated *p* values for the fixed effects for predicting articulation outcomes at 3 and 5 years of age for children using cochlear implants. At age 3, earlier age of hearing aid fit, higher nonverbal IQ, and program were significant predictors of higher articulation outcomes. Children receiving intervention at Hearts for Hearing were predicted to have articulation outcomes 17.4 points higher than children receiving intervention at the Moog Center at age 3. However, at 5 years of age, there were no significant predictors of articulation outcomes. Figure 4 shows the distribution of the articulation scores for the Moog Center and Hearts for Hearing groups at 3 and 5 years of age for children using cochlear implants. Between programs, articulation outcomes were significantly different at age 3, but not at age 5.

Children Using Binaural Hearing Aids

The following results are for children using hearing aids. LME regression analyses were used to analyze how LSL intervention factors contributed to expressive language scores in children at Hearts for Hearing and the Moog Center when controlling for important demographic and audiological variables for children using binaural hearing aids. Table 7 shows the regression weights and the associated significance values for predicting expressive language outcomes at 3 years and 5 years of age. At 3 years of age, higher number of LSL intervention hours was associated with higher expressive language outcomes. Higher nonverbal IQ and better hearing thresholds were associated with higher expressive language outcomes at age 3 as well (Table 7). Similarly, higher nonverbal IQ was associated with higher expressive language outcomes at age 5. Figure 5 shows the distribution of the expressive language scores for the Moog Center and Hearts for Hearing groups with binaural hearing aids at 3 and 5 years of age. Figure 6 shows a scatterplot of the expressive language scores as a function of hours of LSL services received by 3 years of age. As shown in Figure 6, a statistically significant

Table 5

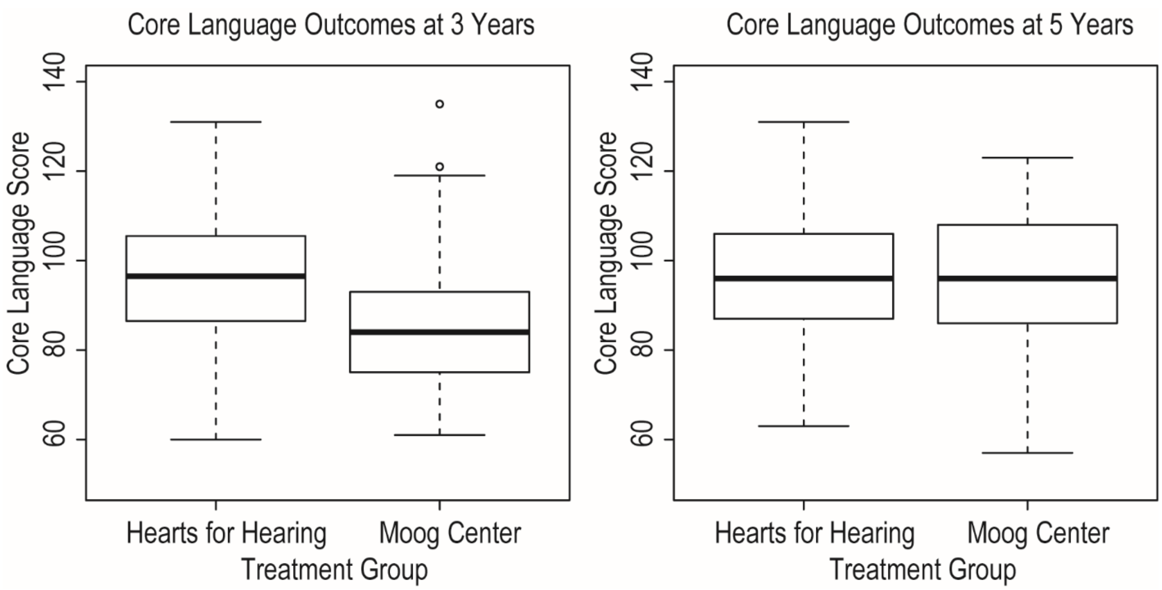
Regression Analysis Results of Cochlear Implant (CI) Language Core Outcomes at 3 and 5 Years of Age

Language Core	3 years of age ($R^2 = 0.35$)			5 years of age ($R^2 = 0.2$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	81.7	3424.9	< .0001	119.5	1723.5	< .0001
Maternal Education		5.0	.009		0.7	.51
High School	-10.75			-8.13		
Some college	-10.7			-2.4		
College graduate	0			0		
Nonverbal IQ	0.21	2.3	.13	-0.09	0.35	.51
Age HA (months)	-0.52	7.6	.008	-0.16	1.2	.29
Age 1st CI (months)	-0.05	0.5	.47	-0.22	1.6	.21
Treatment Group		10.8	.002		0.73	.39
Hearts for Hearing	0			0		
Moog Center	-15.3			-12.7		
Age enrollment LSL	-0.02	1.47	.22	-0.21	1.2	.29
LSL Intervention Hours	0.02	1.95	.17	0.006	0.7	.4

Note. HA = hearing aid; IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 3

Core Language Scores for Children with Cochlear Implants at 3 and 5 Years Old



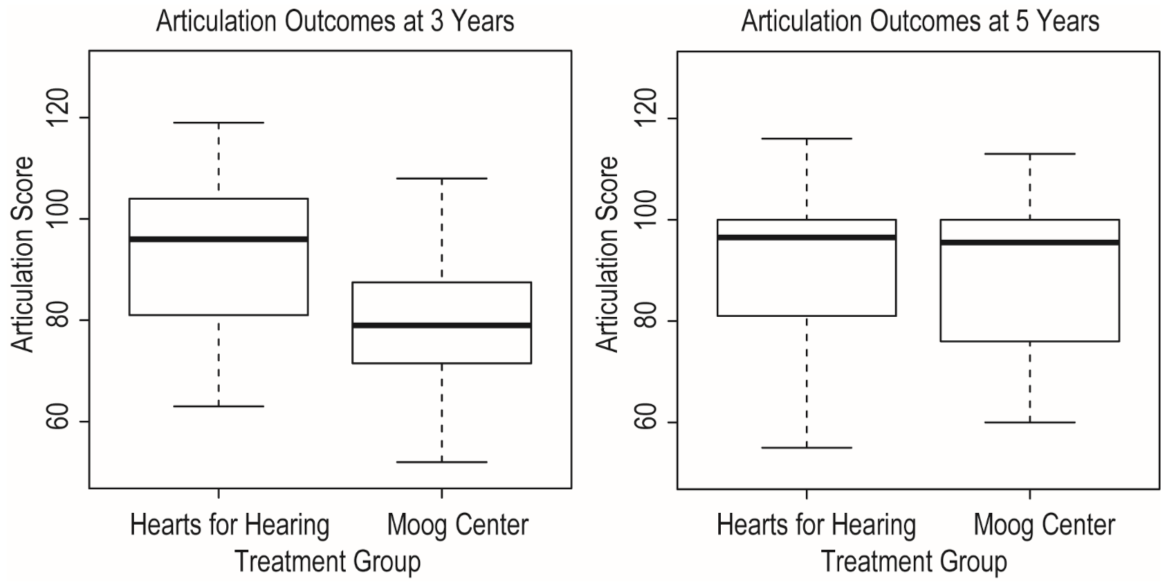
Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers, denoted as circles, are values greater than 1.5 times the interquartile range.

Table 6
Regression Analysis Results of Cochlear Implant (CI) Articulation Outcomes at 3 and 5 Years of Age

Articulation	3 years of age ($R^2 = 0.40$)			5 years of age ($R^2 = 0.13$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	58.9	2542.9	< .0001	80.08	1213.5	< .0001
Maternal Education		2.16	.12		1.07	.36
High School	-7.7			8.5		
Some college	-8.2			5.7		
College graduate	0			0		
Nonverbal IQ	0.34	3.99	.05	0.09	0.05	.82
Age HA (months)	-0.5	7.9	.007	0.14	0.001	.97
Age 1st CI (months)	0.04	.03	.86	-0.05	0.05	.83
Treatment Group		16.8	.0002		1.3	.26
Hearts for Hearing	0			0		
Moog Center	-17.4			-18.5		
Age enrollment LSL	-0.04	0.04	.84	0.08	0.08	.77
LSL Intervention Hours	0.02	0.01	.9	0.008	0.93	.34

Note. HA = hearing aid; IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 4
Articulation Scores for Children with Cochlear Implants at 3 and 5 Years Old



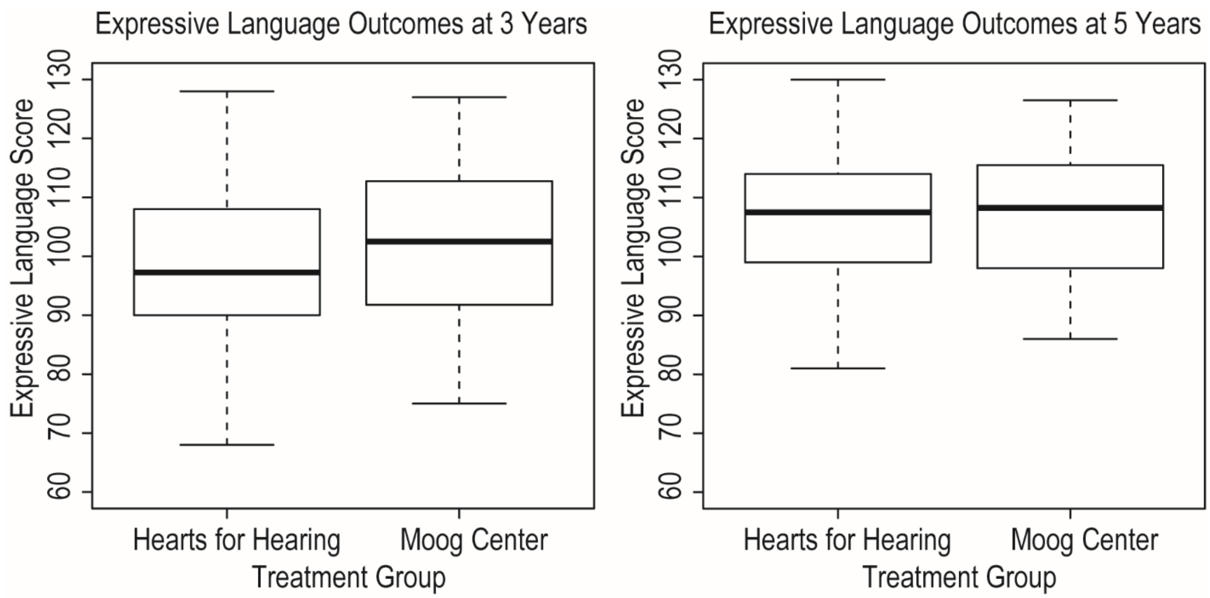
Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers are values greater than 1.5 times the interquartile range.

Table 7
Regression Analysis Results of Hearing Aid (HA) Expressive Language Outcomes at 3 and 5 Years of Age

Expressive Language	3 years of age ($R^2 = 0.28$)			5 years of age ($R^2 = 0.26$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	84.3	740.2	< .0001	98.6	5768.5	< .0001
Maternal Education		2.5	.08		2.4	.09
High School	-6.2			-6.1		
Some college	-5.0			-8.7		
College graduate	0			0		
Nonverbal IQ	0.14	5.3	.02	0.13	4.9	.03
Age HA (months)	-0.07	0.73	.39	-0.09	1.4	.25
Degree Hearing Loss		3.4	.02		0.47	.7
Mild	0			0		
Moderate	-3.1			-2.6		
Moderate-Severe	-11.12			-5.2		
Severe-Profound	-6.5			-0.8		
Treatment Group		0.05	.82		0.0001	.99
Hearts for Hearing	0			0		
Moog Center	-1.45			-14.3		
Age enrollment LSL	0.06	0.12	.72	-0.04	0.13	.72
LSL Intervention Hours	0.02	6.4	.01	0.009	2.2	.15

Note. IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

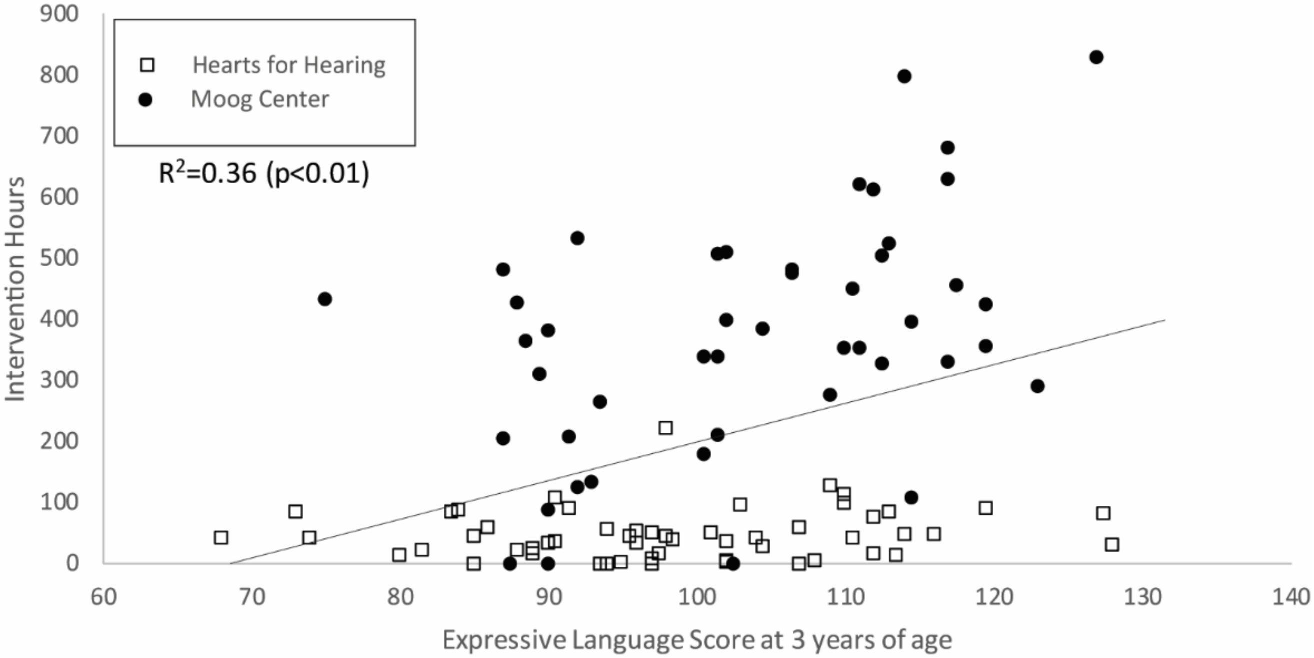
Figure 5
Expressive Language Scores for Children with Hearing Aids at 3 and 5 Years Old



Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers are values greater than 1.5 times the interquartile range.

Figure 6

Expressive Language Scores as a Function of Hours of LSL Services Received by Children with Hearing Aids by 3 Years of Age



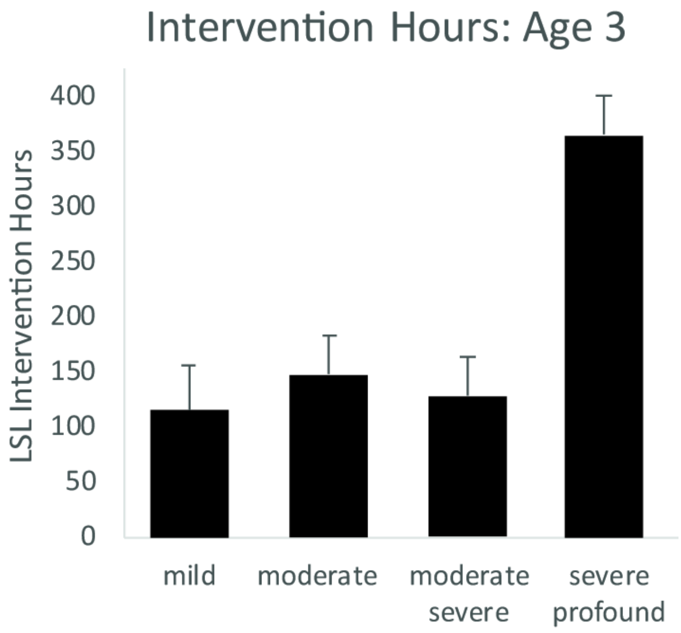
Note. R^2 represents the correlation between intervention hours and expressive language scores across both treatment groups. LSL = Listening and Spoken Language.

but weak positive correlation exists between expressive language at 3 years of age and number of LSL hours from birth to 3 years of age for children using binaural hearing aids across treatment groups. However, this relationship is likely driven by the Moog Center group as the correlation between LSL hours and expressive language increases when only children from the Moog Center are included in the analysis (Figure 6). Figure 7 shows the number of LSL intervention hours by degree of hearing loss. As shown, children with severe to profound hearing loss received significantly more hours of LSL intervention than their peers with lesser degrees of hearing loss. Between programs, expressive language outcomes were not significantly different at age 3 or age 5.

LME regression analyses were used to analyze how LSL intervention factors contributed to receptive language scores in children at Hearts for Hearing and the Moog Center. The regression weights and associated significance values associated with receptive language outcomes at 3 years and 5 years of age for children using binaural hearing aids are displayed in Table 8. LSL services, maternal education and nonverbal IQ were the only significant predictors of receptive language at age 3, and nonverbal IQ was the only significant predictor of receptive language at age 5 (Table 8). Figure 8 shows the distribution of the receptive language scores for the Moog Center and Hearts for Hearing groups with hearing aids at 3 and 5 years of age for children using binaural hearing aids. Between programs, receptive language outcomes were not significantly different at age 3 or age 5.

Figure 7

LSL Intervention Hours Received by 3 Years of Age as a Function of Degree of Hearing Loss for Children with Hearing Aids



Note. Error bars represent standard error of the mean. LSL = Listening and Spoken Language.

Table 8

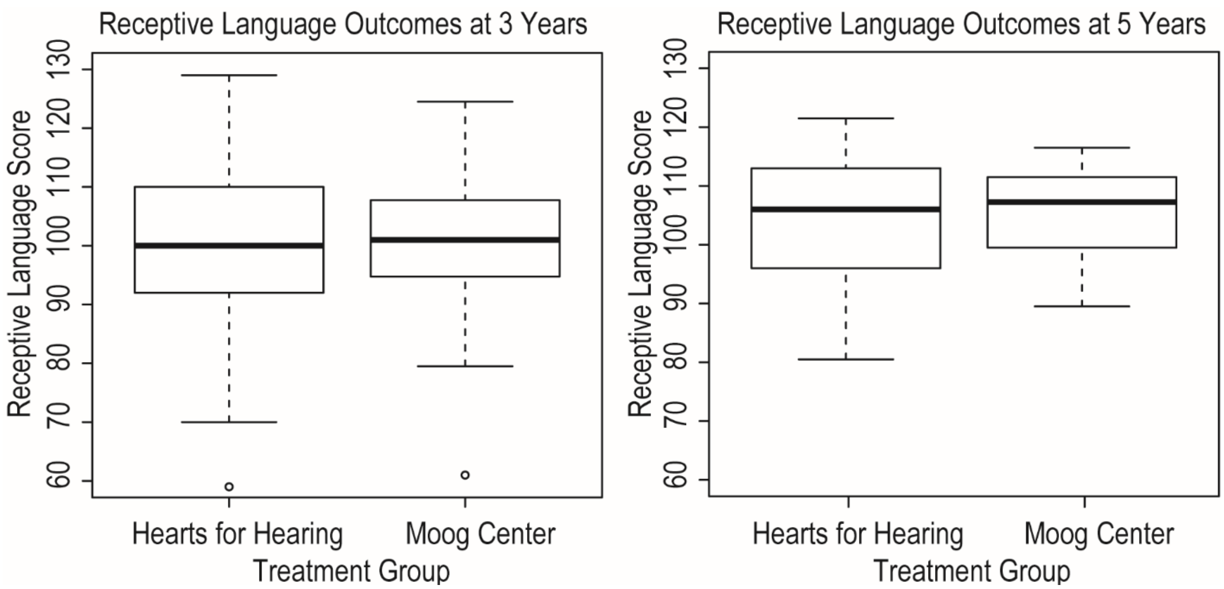
Regression Analysis Results of Hearing Aid (HA) Receptive Language Outcomes at 3 and 5 Years of Age

Receptive Language	3 years of age ($R^2 = 0.23$)			5 years of age ($R^2 = 0.25$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	94.01	7453.6	< .0001	94.8	6325.7	< .0001
Maternal Education		3.9	.02		0.48	.62
High School	-8.3			-2.3		
Some college	-5.2			-5.0		
College graduate	0			0		
Nonverbal IQ	0.13	4.4	.04	0.17	5.62	.02
Age HA (months)	-0.13	1.1	.31	-0.004	0.46	.49
Degree Hearing Loss		1.4	.26		2.17	.10
Mild	0			0		
Moderate	-4.6			-8.1		
Moderate-Severe	-8.04			-9.2		
Severe-Profound	-7.5			-11.5		
Treatment Group		0.13	.72		0.55	.46
Hearts for Hearing	0			0		
Moog Center	-5.8			-4.2		
Age enrollment LSL	0.11	0.02	.89	-0.07	0.25	.62
LSL Intervention Hours	0.02	3.5	.06	0.004	0.59	.44

Note. IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 8

Receptive Language Scores for Children with Hearing Aids at 3 and 5 Years Old.



Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers, denoted as circles, are values greater than 1.5 times the interquartile range.

LME regression analyses were used to analyze how LSL intervention factors contributed to core language outcomes in children at Hearts for Hearing and the Moog Center at age 3 and age 5 for children using binaural hearing aids. Table 9 shows the regression weights and the associated significance values for predicting core language outcomes at 3 years and 5 years of age. At age 3, higher maternal education was associated with higher core language outcomes, whereas greater degrees of hearing loss were associated with significantly poorer core language outcomes. At age 5, earlier age of hearing aid fitting and higher nonverbal IQ were associated with better core language outcomes (Table 9). Figure 9 shows the distribution of core language scores for the Moog Center and Hearts for Hearing groups with hearing aids at 3 and 5 years of age. Between programs, core language outcomes were not significantly different at age 3 or age 5.

Table 10 displays the regression coefficients and associated *p* values for the fixed effects for predicting articulation outcomes at 3 and 5 years of age for children using binaural hearing aids. LSL services at age 3, earlier age at hearing aid fitting was associated with significantly better articulation outcomes. At age 5, higher nonverbal IQ was associated with better articulation outcomes (Table 10). Figure 10 shows the distribution of the articulation scores for the Moog Center and Hearts for Hearing groups with hearing aids at 3 and 5 years of age for children using binaural hearing aids. Between programs, articulation outcomes were not significantly different at age 3 or age 5.

Table 9

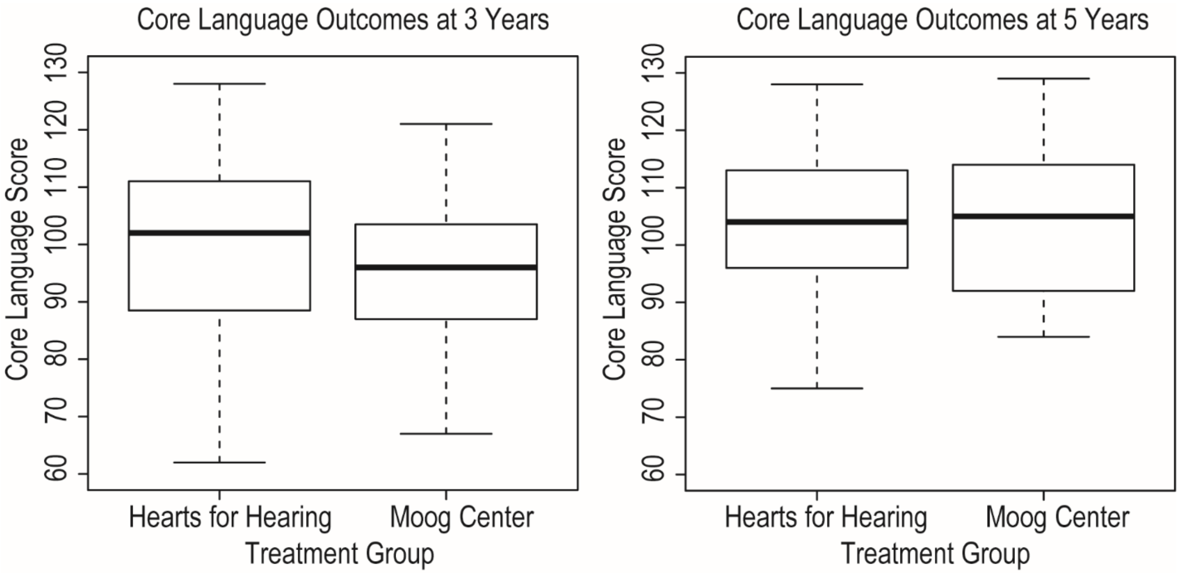
Regression Analysis Results of Hearing Aid (HA) Core Language Outcomes at 3 and 5 Years of Age

Core Language	3 years of age ($R^2 = 0.25$)			5 years of age ($R^2 = 0.43$)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	99.9	4763.4	< .0001	100.9	3947.8	< .0001
Maternal Education		3.4	.04		1.45	.25
High School	-6.6			-5.4		
Some college	-7.7			-11.4		
College graduate	0			0		
Nonverbal IQ	0.08	1.7	.20	0.15	9.8	.003
Age HA (months)	-0.19	0.8	.38	-0.32	7.4	.01
Degree Hearing Loss		3.6	.02		1.2	.33
Mild	0			0		
Moderate	-5.2			-3.2		
Moderate-Severe	-14.2			-12.34		
Severe-Profound	-9.14			-10.4		
Treatment Group		1.1	.29		0.3	.58
Hearts for Hearing	0			0		
Moog Center	-10.4			-15.9		
Age enrollment LSL	0.17	0.22	.64	-0.05	0.12	.73
LSL Intervention Hours	0.02	2.2	.14	0.01	2.7	.11

Note. IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 9

Core Language Scores for Children with Hearing Aids at 3 and 5 Years Old



Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers are values greater than 1.5 times the interquartile range.

Table 10

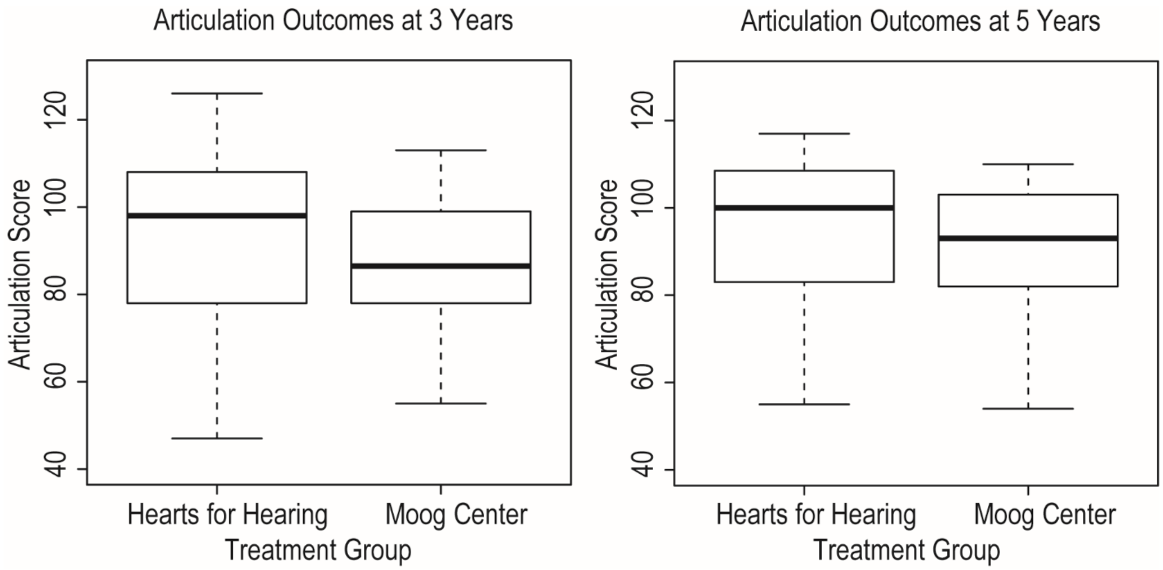
Regression Analysis Results of Hearing Aid (HA) Articulation Outcomes at 3 and 5 Years of Age

Articulation	3 years of age (R^2 = 0.21)			5 years of age (R^2 = 0.32)		
Effect	Parameter	*F* Value	*p* Level	Parameter	*F* Value	*p* Level
Intercept	101.5	1965.6	< .0001	54.5	1403.0	< .0001
Maternal Education		2.25	.11		1.6	0.21
High School	1.13			0.78		
Some college	-7.9			15.6		
College graduate	0			0		
Nonverbal IQ	-0.03	0.19	.65	0.57	8.8	.005
Age HA (months)	-0.47	4.8	.03	-0.29	2.13	.15
Degree Hearing Loss		0.81	.49		0.12	.95
Mild	0			0		
Moderate	7.04			0.89		
Moderate-Severe	-0.47			-0.14		
Severe-Profound	2.92			6.9		
Treatment Group		2.2	.15		2.2	.15
Hearts for Hearing	0			0		
Moog Center	-5.8			-11.4		
Age enrollment LSL	0.02	0.03	.87	-0.004	0.0002	.99
LSL Intervention Hours	-0.006	0.10	.75	0.0006	0.004	.95

Note. IQ = intelligence quotient; LSL = listening and spoken language program. Parameter represents the Beta coefficient from the analysis.

Figure 10

Articulation Scores for Children with Hearing Aids at 3 and 5 Years Old



Note. The median of the distribution is denoted by the horizontal black line in the box, and the edges of each box represent the 25th and 75th percentiles of the distribution. The whiskers extend to the minimum and maximum individual data points that are not outliers. Outliers are values greater than 1.5 times the interquartile range.

Discussion

This is the first study to show age-appropriate listening and spoken language (LSL) outcomes by 5 years of age for children who received LSL services at two different programs focused on parent and child-centered LSL services and early audiologic intervention. However, service provision between the two programs differs in referral processes, setting, amount of child-directed services provided, and amount of parent coaching offered.

Following is a discussion of the outcomes and factors influencing those outcomes for children using cochlear implants and binaural hearing aids from two different LSL programs.

Children Using Cochlear Implants

For children using cochlear implants, 3 primary differences existed between the participants in the two programs. First, at Hearts for Hearing, children began receiving LSL services at an average age of 7 months, whereas children from the Moog Center began receiving LSL services beginning at an average age of 20 months. Second, the children from Hearts for Hearing were fitted with hearing aids at an earlier age than children from the Moog Center. Third, children from Hearts for Hearing received fewer hours of LSL intervention by 3 years of age (mean of 75.9 hours) and 5 years of age (mean of 163.9 hours) as compared to their counterparts at the Moog Center (356.04 and 1547.9 hours at 3 and 5 years, respectively).

For children using cochlear implants, those attending Hearts for Hearing typically achieved better LSL outcomes at 3 years of age compared to children from the Moog Center, but by 5 years of age, there were no differences in LSL outcomes between the two programs. As a result, the advantages of early amplification and early entry into LSL programs are illustrated in the relatively better outcomes obtained by the children from Hearts for Hearing at 3 years of age. Fewer LSL hours may be necessary to achieve age-appropriate listening and spoken language outcomes when LSL intervention is initiated and hearing aids are fitted at an early age. Moreover, the benefits of intensive LSL intervention are illustrated in the accelerated progress made by the children from the Moog Center between 3 and 5 years of age. A greater number of LSL intervention hours at a later age may allow children who have later access to LSL services and later-fit hearing aids to achieve age-appropriate LSL outcomes by school-age entry. Given that the present study did not include children with neurocognitive disabilities, the results may not be representative of the entire population of children using cochlear implants. Some children may need additional LSL services to optimize listening and spoken language outcomes, regardless of the age at which LSL intervention is initiated or when hearing aids are fitted.

For children using cochlear implants at 3 years of age, on average, better LSL outcomes were obtained by children who had been fitted with hearing aids at an earlier age. The benefits of early amplification have been clearly established in the literature (Ching et al., 2018; Moeller et al., 2015). Maternal education and nonverbal IQ also were associated with better LSL outcomes at 3 years of age. Again, previous research has shown each of these factors to be associated with better LSL outcomes (Ching et al. 2018; Moog & Geers, 2003; Niparko et al., 2010). Additionally, a greater number of LSL intervention hours was predictive of better expressive language outcomes at 3 years of age, a finding that is consistent with that of Geers and colleagues (2019).

Of interest, none of the independent variables under study, including hours of LSL intervention, were predictors of LSL outcomes for children with cochlear implants at 5 years of age. The finding that total number of LSL hours did not predict LSL outcomes differs from the finding of Geers and colleagues (2019) but is similar to the findings of Chu and colleagues (2019). Although 5-year outcomes did not differ between programs, children at the Moog Center had higher average LSL intervention hours. Children at Hearts for Hearing may have achieved age-appropriate LSL outcomes because they were identified with hearing loss at an earlier age, fitted with hearing aids earlier, and their parents were coached to create a language-rich listening environment at an earlier age. These steps may have allowed children from Hearts for Hearing greater access to an enriching LSL model throughout a longer portion of the critical period of language development.

Children from the Moog Center showed impressive improvement in LSL abilities from ages 3 to 5 years. This finding is consistent with Ching et al. (2018) where improvements in LSL development were measured from 3 to 5 years of age. Together, the current study and the Ching et al. (2018) study indicate intensive LSL intervention can mitigate delays in LSL outcomes that occur at early ages. Of note, the variance in the standardized language scores of the children who participated in this study was similar to the variance observed in these measures for children with typical hearing. Additional research is needed to determine the dosage of LSL services required to obtain age-appropriate listening and spoken language outcomes for children who receive LSL services at later ages.

Children Using Binaural Hearing Aids

The results of this study suggest that, on average, children who use binaural hearing aids, receive LSL intervention at a program specializing in listening and spoken language development, and have no neurocognitive disabilities achieve age-appropriate LSL outcomes by 3 or 5 years of age. Unlike the findings for children using cochlear implants, there were no differences in LSL outcomes at 3 years of age between the two programs. Because the mean age of hearing aid fitting and program enrollment were similar between the two programs, it is probable that early access to spoken language via hearing aids positively influenced LSL outcomes for children in both programs. However, there were some demographic and audiologic differences present for the children from the two LSL programs. Children from Hearts for Hearing had lower non-verbal IQ, mothers with lower education levels, and families with lower SES, whereas a greater percentage of children from the Moog Center fitted with hearing aids had severe to profound hearing loss.

As with the children using cochlear implants, the number of LSL intervention hours provided to children with hearing aids was not largely predictive of the LSL outcomes, with the lone exception of greater LSL hours associated with better expressive language at 3 years of age. Despite the similar outcomes between programs, LSL intervention hours differed substantially with averages at 5 years of 1350.9 hours at the Moog Center and 103.4 hours at Hearts for Hearing. Of note, higher non-verbal IQ, greater levels of maternal education, earlier age at hearing aid fitting, and better unaided pure tone thresholds were associated with better LSL outcomes for children with hearing aids, findings which are consistent with previous research (Ching et al., 2018; Moeller et al., 2015). Also of note, the variance in the standardized language scores of the children who participated in this study was similar to the variance observed in these measures for children with typical hearing.

Study Limitations

As previously discussed, the current study did not include children with neurocognitive disabilities. Cupples et al. (2018) reported the presence of an additional disability other than hearing loss in 39% of the children participating in the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study. Consequently, the results of the current study cannot be applied to all children who are deaf or hard of hearing. Additional research is needed to better understand the role of LSL intervention dosage on listening and spoken language outcomes of children with neurocognitive disabilities.

Moreover, the children in the current study were all active participants in one of the two LSL programs from which the children were recruited to be included in this research. Children who are deaf or hard of hearing may achieve poorer LSL outcomes if their families do not have the same level of access and/or demonstrate a commitment to LSL services that is similar to the access and commitment made by the families of the children in the current study. Additional research is needed to explore LSL outcomes of children whose families do not have a consistent access or commit to services at a specialized LSL program.

Additionally, as noted in the Method section of this paper, not every child who was evaluated at 3 years of age also was evaluated at 5 years of age. It is impossible to know how the study results would have been affected if all children in the study also were evaluated at 5 years of age. It is possible that some of the children who were not enrolled in intervention at 5 years of age had ceased services because they had developed excellent listening and spoken language skills. If this is true, then inclusion of the test scores for those children at 5 years of age may increase the mean scores. Once again, however, it is impossible to speculate on the effect that participant attrition at 5 years of age has on the study results evaluated at 5 years of age.

Furthermore, information pertaining to audiologic intervention was not included in the current study. For instance, complete hearing aid and cochlear implant datalogging records (i.e., usage time) were not available. Also, there were too many discrepancies regarding the manner in which speech perception scores were obtained across participants (e.g., types of speech perception tests that were administered, presentation level, recorded versus monitored live voice, quiet vs. noise, etc.) to allow for speech perception abilities to be included as a factor in the prediction of LSL outcomes. Additional research is needed to determine the relationship between LSL intervention dosage, audiologic variables, and LSL outcomes. In addition, future work will need to examine effects of service delivery dosage on children implanted at less than 12 months compared to those implanted at 12–18 months of age.

Conclusions

The results of this study indicate age-appropriate LSL outcomes are probable for children who have typical neurocognitive abilities and whose families have access and actively commit to LSL services from a specialized LSL program. Non-verbal IQ and maternal education levels also influence LSL outcomes. Total hours of LSL intervention do not serve as a predictor of LSL outcomes at 5 years of age. However, when poorer-than-expected outcomes are measured at 3 years of age, it may be possible to achieve age-appropriate LSL outcomes by age 5 with intense LSL intervention from 3 to 5 years of age. Children who have earlier access to hearing technology and LSL intervention may need fewer LSL hours to achieve age-appropriate LSL outcomes; however, those who are later identified and later enrolled in LSL intervention may require more hours of services to achieve the same age-appropriate LSL outcomes. Early identification of hearing loss, early amplification, and early intervention are highly influential factors affecting LSL

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