Outcomes for Children With HL: Effects of Age of ID, Sign Support, and Auditory Prosthesis

Susan Nittrouer

Ohio State University
Columbus, OH

Abstract

The purpose of the project reported here was to examine the effects of three independent variables on developmental outcomes for children with hearing loss (HL): age of identification of hearing loss, whether or not spoken language input was supported with signs and whether children used hearing aids (HAs) or cochlear implants (CI). Children with and without hearing loss were tested multiple times between 12 and 48 months of age, at their 6-month birthdays. Dependent variables were selected to examine all aspects of child development: receptive and expressive language, psychosocial components of personality, deleterious behaviors, adaptive behaviors, parental language style, and levels of parenting stress. Results support several main findings:

1. *None of the independent variables had any significant effect on any dependent variable unrelated to language.*
2. *Mean levels of all language skills were delayed for all groups of children with HL, even those children identified at birth with only moderate losses that could be appropriately aided with HAs.*
3. *For children with losses identified at birth, the use or nonuse of signs to support spoken language input did not affect language outcomes in the long run.*
4. *Within the restricted range examined here, age of identification did not affect language outcomes, if children were not getting sign support; children with late-identified hearing loss receiving sign support were more delayed on all language measures than other children with HL.*
5. *Regarding prosthesis, some experience using HAs was associated with better outcomes, even if children eventually received CIs.*
6. *A parental language style that involved being very verbally responsive to the child's communicative attempts was strongly associated with positive language outcomes.*

Introduction

This presentation at the national Early Hearing Detection and Intervention meeting held in February 2008 served as a progress report of an ongoing research project examining outcomes for children with hearing loss (HL). This project is funded by the National Institute on Deafness and Other Communication Disorders.

The project was designed to examine the effects of three factors long considered by professionals to have a significant impact on the development of children with HL: age of identification of that HL, whether or not some form of manual signs are used to supplement spoken language input, and the type of prosthesis worn by the child.

Age of Identification of HL

The notion that there are critical periods for a wide variety of developmental outcomes has been applied to our ideas of how and when we should intervene for children with HL. The notion that there may be a critical period for language acquisition suggests that we must provide language input as soon after birth as possible, using sign language if spoken language is inaccessible to a child. The notion that there may be a critical period for bonding with others has further supported this contention, because it means that parent and child must have a way to communicate in order for that bonding to occur.

Sign Use

Formal sign languages have long been recognized as culturally valid ways for individuals with HL to communicate, and that view is shared by investigators on this project. Recently, the idea has gained popularity that manual signs can actually facilitate the acquisition of spoken language, for children with normal hearing (NH) and HL alike. It is this motivation for using manual signs with children that was explored by this work.

Auditory Prostheses

At the outset of data collection in 2003, the expectation was that children with HL participating in this study would have bilateral hearing aids (HAs) or one cochlear implant (CI). However, clinical practice has expanded to include all combinations possible of HAs and CIs, and so we explored the effects of all these possibilities.

Methods

Participants

Data are reported for 204 children: 86 with NH and 118 with HL. These children came from 24 test sites across the country. All children were born between August 1, 2002 and June 30, 2004. All children had unremarkable prenatal histories and no complications at the time of birth. No child had a major health condition other than HL that could delay language, cognitive, or motor development. All children had parents with NH who reported speaking only English to their children. All children were living with their parents. Children in the study with NH all passed a hearing screening at birth and, at 3 years of age, they also passed an audiological screening of the frequencies 500, 1,000, 2,000, and 4,000 Hz presented at 20 dB HL to each ear separately. Fifty-

one percent of participants were female. SES varied within each group, but means and distributions were similar across all groups. Thirty-three of the children with NH had parents who supported spoken language input with signs, and 44 of children with HL had parents who did so.

Children with HL all had better ear pure tone (500, 1,000, and 2,000 Hz) averages (BE PTAs) poorer than 50 dB HL. Seventy-six of the children with HL had their losses identified, HAs fit, and intervention started before the age of 6 months. The other children were not identified as having a hearing loss until after the age of 12 months.

However, all of these children subsequently had their losses identified, an appropriate prosthesis fit, and intervention started before the age of 30 months. There was no reason to suspect a progressive or sudden-onset hearing loss for any of these late-identified children, and so the assumption was that their losses were congenital. All children had stable losses for the duration of data collection. Table I shows mean BE PTA for various groups of children.

Table 1. Mean better ear pure-tone average (BE PTA) thresholds for various groups, with standard deviations (SDs). Groups based on prosthesis were according to what children had at 48 months of age.

	Mean	SD
Children receiving sign support	90.6	27.3
Children not receiving sign support	91.3	21.3
Children with cochlear implants (CIs)	103.7	14.5
Children with hearing aids (HAs)	64.2	10.8
Of those children with CIs, those with:		
bilateral CIs	105.5	13.6
CI and HA combination	99.1	15.3
one CI	105.5	14.8

All parents of children with HL reported wanting spoken language to be their children's primary communication mode: Specifically, they indicated that it was their goal that their children be mainstreamed in regular classrooms without the need of sign-language interpreters. All parents reported that their children used their auditory prostheses consistently while they were awake. Children with HL were all seen by audiologists at reputable centers every few months, and so we assume their prostheses were appropriately fit. Until 36 months of age, all children and their families received intervention at least once per week by professionals who generally had at least Master's degrees in relevant disciplines. After 36 months of age children with HL attended preschools at least 12 hours per week. Sixty-six percent of children with HL had at least one CI; all others had bilateral HAs. We tracked whether CI users had just 1 CI, 2 CIs, or a CI/HA combination. All children with CIs had versions available since 2003: 48 with Cochlear, 27 with Advanced Bionics, and 4 with MED-EL. Mean age of receiving a first implant was 15 months of age.

Dependent Variables

An important consideration in the design of this study was that we wished to examine all aspects of behavioral development in children with HL, and so we selected dependent measures that allowed us to examine

development in areas not related to language, as well as in areas related to language. The nonlinguistic domains examined were: psychosocial development, such as whether or not children with HL were more introverted than children with NH and whether they showed signs of aggression more frequently; adaptive behavior, such as whether children met developmental milestones on time for behaviors like feeding themselves; parenting stress; and nonverbal cognition. For these nonlinguistic measures, we used all commercially available instruments.

When it came to measures related to language, we wished to examine how well children comprehend language through audition; expressive vocabulary; communicative function (pragmatics); form of communication (real words, vocalizations, or manual gestures); early syntax and grammar; acoustic structure of their speech production; and intelligibility. For these experimental foci, we used commercially available instruments judiciously. First, we decided exactly what skills we wished to measure, studied the commercial instruments available, and used one only if it examined what we were interested in. We made minor modifications, if necessary, to bring an instrument into line with our purposes. Finally, we did not compare our participants with HL to published norms, but rather to means collected from our typically developing children with NH who matched our participants with HL in terms of gender, socioeconomic status, and geographic location.

Procedures

Children were tested every 6 months, within one month of their 6-month birthday. Data were not collected as part of the children's regular clinical interventions, but rather outside of intervention. The individuals collecting data, termed "examiners," collected data outside of regular working hours: either after school or on weekends. The examiners were not working with the children whom they tested. All paperwork regarding this project was kept at the central facility (Ohio State University), and packets were sent to examiners when it came time to test a child informing the examiner that data collection was required for a participant.

All examiners attended two training sessions at which we reviewed procedures carefully. After they returned home, they practiced test procedures with children whose data were not included in the analyses (i.e., "practice" participants). Each test session consisted of having a parent complete questionnaires (about their stress levels, as well as their children's behavior and vocabularies) and videotaping the parent and child interact using standard sets of toys. These videotapes served as the material for examining both the child's communicative function and form and the parent's language.

After data were collected from a participant, the examiner packaged up all the paper forms and the videotape, and mailed them back to the central facility. These materials were stripped of the participant's name and other identifying information. Graduate assistants then scored all materials under the watchful eye of laboratory staff. These procedures helped to maintain objectivity and reliability in the data.

Results

Clearly, within the constraints of this brief report not all details can be provided regarding results. Readers are referred to more substantive papers arising from this project for information on the detailed analyses.

Nonlinguistic Measures

Results for all measures unrelated to language can be summed up by stating that generally no differences were found. **(Finding 1)** Looking across all test times, parents did not report significantly more overall stress if their children had HL than if their children did not. Similarly, they did not report less stress if they were using signs to communicate with their children than if they were not. Children generally did not demonstrate differences in behavior based on hearing status, sign use, or age of identification of HL.

Language Measures

In contrast to the nonlinguistic measures, all measures related to language demonstrate significant trends, and these trends were similar across all language measures.

Figure 1 displays mean raw scores for the Expressive One-Word Picture Vocabulary Test (EOWPVT; Brownell, 2000). In this figure, results for children with late-identified HL are not included. Error bars are not shown, but the standard error of the mean (SEM) = 0.66, and the standard deviation (SD) = 10. This figure illustrates the second two findings listed in the Abstract: **(Finding 2)** Hearing loss had significant deleterious effects on language development, $F(1,282) = 70.48$, $p < .001$, and that was true even for children identified at birth, even if they had losses in the moderate range that could be fit with bilateral HAs. **(Finding 3)** The use of signs had no long-term effects on the development of language for children with NH, or for children with HL whose losses were identified shortly after birth. In other words, using sign language before children were old enough to receive cochlear implants, if implants were prescribed, did not facilitate the acquisition of spoken language. It is emphasized that although this figure displays mean raw scores for the EOWPVT, these two trends are well-replicated in all dependent measures related to language.

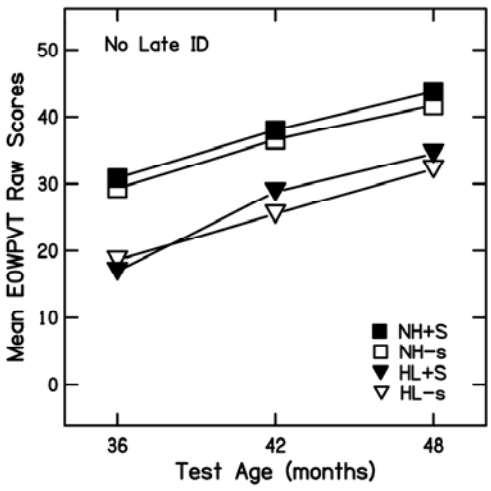


Figure 2 displays mean raw scores for the EOWPVT for children with HL. Results are separated depending on the age of identification, prosthesis, and whether children were in programs that used signs or not. **Finding 4** is illustrated in this figure: Age of identification was not significant, except for late-identified children with whom signing was being used. This trend resulted in a significant Age of Identification x Sign interaction, $F(1,207) = 6.99$, $p = .009$. For the late-identified children there is a clear effect of whether children were receiving sign support or not, $F(1,75) = 19.6$, $p < .001$. Looking at results for the early-identified children only, we observe a significant effect of prosthesis, $F(1,124) = 12.80$, $p < .001$. Children who received CIs trailed children with HAs. In this figure, children with CIs are grouped together, regardless of whether they had one or two CIs and regardless of what they had on the other ear. This effect of prosthesis is not apparent for the late-identified children.

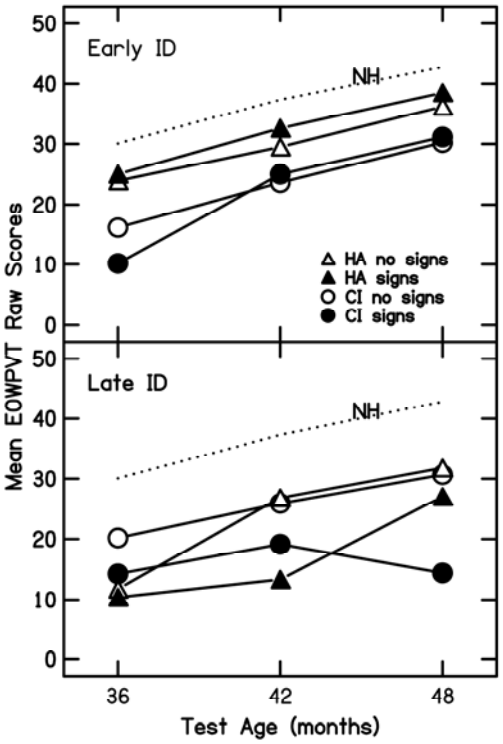
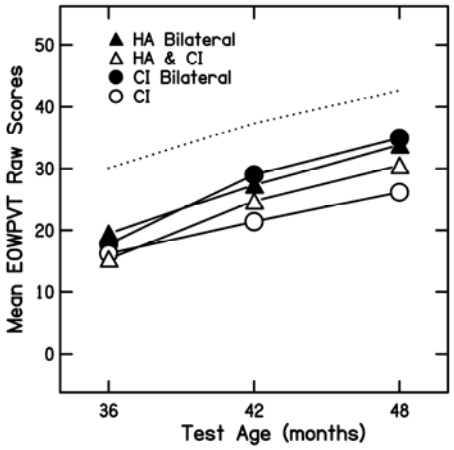
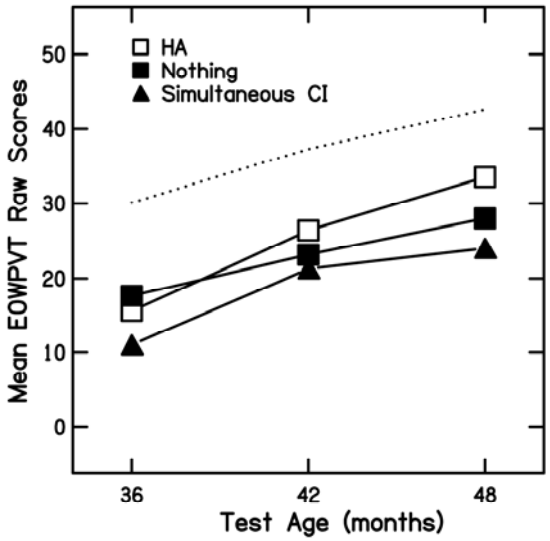


Figure 3 illustrates EOWPVT raw scores for children with HL who had consistent prostheses from 30 to 48 months; that is, children who received simultaneous bilateral implants or a second implant during this time are not included. Here we see that children with just one CI trailed other children with HL in the development of expressive vocabulary. Children with bilateral CIs are performing as well as children with bilateral HAs at 42 and 48 months, and are performing slightly, though not significantly, better than children with HA & CI combinations. On some other language measures, in fact, children with HA & CI combinations are found to be performing slightly better than children with bilateral CIs.



Next, we examined vocabulary growth for children with bilateral implants only, with groups determined by what they had on the unimplanted ear before receiving the second implant. In this analysis, data from children who received a second implant or simultaneous bilateral implants after the age of 30 months are included. Mean age of receiving a second implant, if one was received after 30 months, was 37.5 (SD = 4.5) for children who had an HA on the unimplanted ear before the second implant, as well as for children who had nothing on the unimplanted ear before that second implant. For children who received simultaneous bilateral implants after 30 months age, mean age of doing so was 34.8 (SD = 2.0). Figure 4 presents scores for these children. We see that the children who had an HA in combination with a CI until the time of the second implant are faring better. **(Finding 5)** This result was replicated across dependent language measures.



Finally, correlational analyses performed on various measures of parental and child language revealed strong correlations between how verbally responsive parents were with their children, how many open-ended questions they asked of their children, and how frequently they directed their children to imitate a specific word or phrase. This last correlation was negative in direction, with children generally demonstrating poorer language when their parents expected them to imitate specific words or phrases. **(Finding 6)**

Conclusions and Clinical Implications

The results emerging from this study are supporting some general conclusions and suggestions regarding how to intervene for children with HL. The first and perhaps most striking finding of this study is that in spite of having their HL identified shortly after birth the majority of children in this study were performing roughly one SD below children with NH on all language measures. Such performance is being observed even for children with losses that are only moderate in severity. This result should not be interpreted as evidence that detection of HL shortly after birth is not necessary for optimal outcomes. Instead, this result should serve as a call for us to examine how we are intervening with children once we identify a HL. Second, no evidence was found to indicate that supplementing spoken language with signs facilitates the acquisition of spoken language. This is true even for children who eventually will need a CI. Third, no evidence was found to support the practice of bilateral cochlear implantation. Fourth, it appears that one of the best things we can do to help children with HL is to teach their parents how to be effective communication partners, responding verbally to their children's communicative attempts, providing complete verbal models, and encouraging their children to generate their own language.

It may be helpful to consider the characteristics of the eight children with HL in this study who were found to be performing similarly to children with NH across language measures. These children shared specific traits:

- They all had their HL identified shortly after birth.

- They all had substantial access to acoustic hearing through HAs—four with bilateral HAs and four with HA & CI combinations.
- And finally, they all had parents who asked open ended questions, issued few directives, and modeled complete sentences frequently.

Reference

Brownell, R. (Ed.). (2000). *Expressive One-Word Picture Vocabulary Test* (3rd ed.). Novato, CA: Academic Therapy Publications, Inc.