PPVT-5/EVT-3 Special Group Study: Children with Hearing Loss who Utilize Cochlear™ Implants and Spoken Language

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Children with hearing loss account for slightly over one percent of children receiving special education services in the United States (U.S. Government Accountability Office, 2011), with some studies noting that as many as 14.9 percent of all U.S. children have a hearing loss when including children with unilateral, partial frequency, and mild hearing loss (Niskar et al., 1998). Hearing loss is a multifaceted phenomenon, and clinicians working with children with hearing differences must be aware of the heterogeneity of this population with regard to relevant factors, such as the age of onset of hearing loss, form(s) of communication, early language access, degree of hearing loss, use of assistive technology, and co-morbid conditions. Given the diversity within this population of individuals, interpreting assessment results requires great care and understanding of the individual child. Examiner knowledge and careful consideration of the potential impact that each of the above factors has on the child's development is important.

Consideration of the child's language and communication preferences and abilities is imperative for administration and interpretation of assessment measures. There is a wide variety of communication methods used among children with hearing loss (Day, Costa, & Raiford, 2015). As noted above, the population of children with hearing loss is a dynamic group that includes individuals with a range of hearing levels, educational backgrounds, and language considerations. Some children with hearing loss communicate using more than one method of communication, while other children have a clearly identified preferred primary language or communication method, and some have limited proficiency in any form of communication. The primary communication modalities/methods include American Sign Language (ASL), listening and spoken language, Cued Speech, and total communication, as well as any combination of two or more of these approaches. It is critical to note that within each of these categories, variability exists.

When evaluating the results of a child's Peabody Picture Vocabulary Test™–Fifth Edition (PPVT™-5) and Expressive Vocabulary Test™–Third Edition (EVT™-3) results, a strong understanding of the child's language background, developmental history, and experience with intervention services is critical, and test results should be interpreted with caution. Some children may demonstrate strong competency in one or more language and communication modes, while others may still be developing language/communication proficiency. It is also possible that if the child has cognitive limitations, or was identified with a hearing difference later in development, the child may not have a strong language foundation. Assessment results should be understood and interpreted in the context of the child's receptive and language capabilities. A full review of guidelines for the administration and interpretation of results for children with hearing loss is available in appendix D of the PPVT-5 and appendix E of the EVT-3 manuals.

The current special group study focused on children who primarily use listening and spoken English as a preferred communication modality and are bilateral cochlear implant users. When a child uses solely auditory modalities, spoken language is used without signs, gestures, or other visual representations of the spoken language. Appropriate and consistently functioning technology that allows auditory access to speech sounds, such cochlear implants, is integral to the success of this communication choice.

While children who use auditory/oral modalities generally make use of spoken English, the child's ability to access auditory information should be clarified. This includes gathering background information on the child's hearing history, and requesting the child's most recent audiogram (audiological evaluations should occur at least once a year for individuals with CIs). It should be noted that the presence of an audiological device (i.e., cochlear implant or hearing aid) does not guarantee that the child has full access to spoken language. A child who uses cochlear implants may have auditory access to speech sounds, but may still have difficulty discriminating between some sounds. During testing, the child may be taxed in detecting and understanding the speech of the examiner due to their hearing loss, even with the use of devices, which can result in fatigue and impact results.

In general, interpretation of results should be approached with caution and understood within the context of the child, their language abilities and exposure, auditory access, developmental history, and any modifications of the test (if applicable). Examiners must remain cognizant of the possibility that the presence of a hearing difference, regardless of communication modality, may result in environmental conditions that impede incidental learning. That is, compared to a child with typical hearing, a child with hearing loss may have comparatively limited access to their environment, which reduces exposure and learning opportunities in their everyday life. This is especially relevant for children who were not provided with adequate early language exposure. It is important to carefully consider one's history in an attempt to distinguish between performances related to cognitive functioning and ability, and those aspects of performance that reflect the environmental circumstances for the child.

Published literature on general outcomes for children with hearing differences has been highly variable, with the majority of the published research for children who utilize listening and spoken language focused on language outcomes. For children who utilize cochlear implants, variability of performance has been attributed to several factors. Children with cochlear implants have demonstrated varying degrees of speech comprehension and understanding (Dettman, Pinder, Briggs, Dowell, & Leigh, 2007; Geers, Tobey, Moog, & Brenner, 2008; Holt & Svirsky, 2008; Nicholas & Geers, 2007); and language outcomes are influenced by age of implantation, degree of residual hearing prior to implantation, maternal sensitivity, and socioeconomic status (Niparko et al., 2010; Quittner et al., 2013). For children with hearing loss, early identification and early intervention are also significant factors to consider in terms of language and overall outcomes (Sininger, Grimes, & Christensen, 2010; Yoshinaga-Itano, Sedey, Coutler, & Mehl, 1998), as well as nonverbal cognitive abilities (Geers et al., 2008; Mayne, Yoshinaga-Itano, & Sedey, 2000). As noted, language development must be understood for each child, as it will influence the results of standardized testing, and examiners must make an effort to understand how the child's language history impacts results on assessment measures.

In terms of previously published literature on the performance of children who utilize cochlear implants on the previous editions of PPVT and EVT, variability has also been reported. While many of the published studies recognize the difficulty of generalization for this heterogeneous population, the trends in the literature report lower scores on measures of receptive and expressive vocabulary. The literature reports that performance on receptive vocabulary tests, including the PPVT, in children with CIs falls at least one SD below the average range compared to their hearing peers. In a meta-analysis evaluating vocabulary knowledge in children with cochlear implants, receptive vocabulary outcomes, including PPVT results, fell 20.33 points lower than children with typical hearing (Lund, 2016). Studies that evaluated results of the PPVT specifically also indicated reduced performance outcomes in children with cochlear implants (Dettman et al., 2016; Fagan & Pisoni, 2010; Miyamoto, Colson, Henning, & Pisoni, 2017). Performance results on the EVT have also been lower among children with cochlear implants. Lund (2016) reported an 11.99 point difference on expressive vocabulary tests, including the EVT, compared to results of their hearing counterparts, which is consistent with findings from studies that evaluated EVT results specifically (Geers et al., 2009; Luckhurst, Lauback & Unterstein VanSkiver, 2013; Schorr, Roth, & Fox, 2008).

Several studies indicated that the age of implantation was a significant mediating factor in vocabulary language testing results. For instance, Dettman et al. (2016) compared testing results between children who received cochlear implants by 12 months of age to children who received cochlear implants later in development (i.e., 13-18 months, 14-24 months, 25-42 months, and 43-72 months). Results indicated that children who were implanted before 12 months of age had significantly higher PPVT performance (SS=99.8) than all other age groups, and children in the 13-18 month age group performed significantly better (SS=82.9) than the remaining 3 groups (SS=65.4, 59.8, 59.0, respectively). It should be noted that the children in the 12 month age group were the only children to perform within the average range on the PPVT, whereas the other groups fell below average. These results indicate that the age of implantation, as well as the length of device experience, significantly improve spoken language vocabulary performance. When controlling for how long children have had cochlear implants (i.e., comparing results based on "hearing age" rather than chronological age, results suggest that children with cochlear implants perform within the average range (Fagan & Pisoni, 2010). These results support the notion that extra consideration should be made when determining the norms used for standardization.

The goal of this special population study was to investigate the performance of children with cochlear implants who use listening and spoken English as their primary communication modality on the PPVT-5 and EVT-3. Given the large number of confounds and variability that can exist within this population, the current study aimed to limit the scope of the collected data to a more homogeneous sample, controlling for some known factors that can lead to variability in outcomes (e.g., the presence of comorbid diagnoses that may impact development; access to interventions). Children in the current study were all fit with bilateral cochlear implants that allowed for access to sound, and have been regularly monitored, ensuring auditory access to spoken language. Results were evaluated using a matched control group, controlling for variables such as the child's age, sex, and parent education level.

Based on the results of previous research, it was expected that the children in the current study would have significantly lower mean scores on the PPVT-5 and EVT-3 than a matched control group.

Methods

Measure

The PPVT-5 is an individually administered, norm-referenced, wide-range instrument for assessing receptive vocabulary in children and adults. The instrument measures understanding of words in standard American English, assessing broad vocabulary acquisition. The age range covered for the instrument is 2 years, 6 months through 90 years and older (2:6-90+). The PPVT-5 is available in two forms (Form A and Form B) that are administered individually. Each form contains training items and test items, each consisting of four full-color pictures as response options on a page. During administration, the examiner says a word, and the examinee responds by selecting the picture that best illustrates that word's meaning. The administration of the measure is untimed, but average administration time is 10 to 15 minutes. Administration is available in both paper and pencil and digital formats. This updated edition of the PPVT-5 maintains the basic format of the PPVT-4 while providing updated normative data and refined items so that stimulus word and picture stimuli may be applied to different cultures within the United States.

The EVT-3 is an individually administered, norm-referenced instrument that assesses expressive vocabulary and word retrieval for children and adults. The instrument measures expression and word retrieval in standard American English, assessing broad vocabulary acquisition. The age range covered for the instrument is 2 years, 6 months through 90 years and older (2:6-90+). The EVT-3 is available in two forms (Form A and Form B) that are administered individually. Each form contains training items and test items arranged in increasing difficulty. For each item, the examiner presents a picture and reads a stimulus question, and the examinee responds with one word that provides an acceptable label, answers a specific question, or provides a synonym for a word that fits the picture. The administration of the measure is untimed, but generally takes 10 to 20 minutes, depending on the examinee's age and vocabulary knowledge. Administration is available in both paper and pencil and digital formats. This updated edition of the EVT-3 maintains the basic format of the EVT-2 while providing updated normative data and refined items so that stimulus word and picture stimuli may be applied to differing cultures within the United States.

Participants

The clinical sample consisted of 70 children with cochlear implants. The children ranged from 3 to 17 years of age (M=6.3). Thirty-six of the participants were female and 34 were male. The full demographic data for the group of children with cochlear implants appears in Table 1. Participants were matched to control participants based on age and sex, and the participant's parents' education level.

In order to control for the high heterogeneity of children with cochlear implants, thorough inclusion and exclusion criteria was utilized for the clinical sample. The inclusion criteria outlined that children must be diagnosed with a severe to profound hearing loss in both ears, and must have received bilateral cochlear implant at least 24 months prior to testing with the PPVT-5/EVT-3. Prior to participation in the study, participants had to finish the process of undergoing post-surgical rehabilitation services with members of the aural rehabilitation team, including fitting of the external components of the cochlear implant and activation and programming of the implant and microphone, speech processor, and transmitter. Participants were also required to be in the process of intervention to enhance communication, including auditory training. It was required that participants were considered proficient in English, and English was identified as the primary language spoken by the examinee (bilingual subjects were required to understand and speak English equally well or better in comparison to the other language or languages). Participants with speech delays were permitted to participate (fluency/stuttering or articulation errors), as long as the examinee was intelligible, or the errors included systematic substitutions. Co-morbidities not directly related to language impairment (e.g., ADHD or learning disability in math) were acceptable as long as language functioning was not directly impacted. Participants who were born prematurely were eligible if they did not require extended hospitalization or surgeries that might negatively impact global development. Participants were required to have normal vision with or without corrective lenses, and have the ability to take the test in a standard manner without modifications.

Exclusion criteria for the sample outlined that no examinees without a hearing loss, or examinees with a hearing loss but without a cochlear implant, were eligible. Twin siblings of included examinees, and relatives, close friends, or co-inhabitants of the examiner were excluded from participation. Examinees who were currently admitted to a hospital or mental health facility were excluded from participation. No examinees were permitted who were diagnosed with: disorders reflecting disturbances of the development of the nervous system; genetic or congenital disorders associated with a delay in cognitive, language, social-emotional or adaptive functioning; intellectual disability; Autism Spectrum Disorder; psychiatric diagnoses; seizure disorders and/or a history of seizures, epilepsy, encephalitis, brain surgery (aside from cochlear implantation), or prolonged periods of unconsciousness (i.e., lasting five or more minutes); acquired central nervous system disorders such as a brain tumor or traumatic brain injury; color blindness; and/or global developmental delays. Participants (i.e., their parents/guardians) were compensated for their participation.

The matched control sample was drawn from the pool of nonclinical children who participated in the standardization of the PPVT-5 and the EVT-3. Participants for the matched control sample of nonclinical children were screened for general exclusion criteria used for the PPVT-5 and EVT-3 normative sample. Refer to Chapter 3 Development and Standardization of the PPVT-5 and EVT-3 manuals.

Procedure

The data for children with cochlear implants was collected between December 2017 and June 2018. Examiners who are trained in both the standard administration of the PPVT-5 and EVT-3, and working with children with hearing loss captured response information by administering the measures in the digital formats (conducted using an iPad). Participants were administered the measures without modifications.

The matched control sample was collected between December 2017 and June 2018, concurrent with the PPVT-5/EVT-3 standardization. For the matched control sample, examiners captured response information in the standard manner used for norming. A team of several scorers at Pearson validated all of the administration events. All scores were calculated by Pearson staff using the keyed item scores and the final scoring rules. The final composite norms were then applied. Special population study participants were matched to control participants based on age and sex, and the participant's parents' education level.

Results

The demographic data for the group of children with cochlear implants appears in Table 1.

For this study, education level was based on the number of years of school completed by the child's primary parent/caregiver.

The demographic characteristics of the current sample disproportionately represent children with a parent education level of a bachelor's degree or more; 97.2 percent of participants had a parent education level of at least some college. The group represents children who are Asian and White at a greater proportion than the U.S. population proportion, and children who identify as Hispanic and Black at a smaller proportion than the U.S. population proportion. The sample contains slightly more girls than boys. The focus of this study was children, so within the PPVT-5/EVT-3 age range of 2 years, 6 months to over 90 years of age, individuals under 3 and over 17 years of age are not represented. The majority of the participants were between 3 and 11. Over 94 percent of cases were drawn from the South region of the U.S.

Table 1. Demographic Data for Children with Cochlear Implants

N	70
Age	
Mean	6.3
SD	3.0
Range	3-17
Education[a]	
0–12 years of school, no diploma	—
High school diploma or equivalent (%)	2.8
Some college or technical school, associate's degree (%)	28.6
Bachelor's degree (%)	68.6
Race/Ethnicity	
Black (%)	2.9
Asian (%)	8.5
Hispanic (%)	11.4
Other (%)	2.9
White (%)	74.3
Region	
Midwest (%)	5.7
Northeast	—
South (%)	94.3
West	—
Sex	
Female (%)	51.4
Male (%)	48.5

Note. Except for sample size (N) and age, data are reported as percentages. Total percentage may not add up to 100 due to rounding.
[a] Education = parent education level

Table 2.1 presents the mean composite scores on the PPVT-5 for the children with cochlear implants and matched control group.

Table 2.2 presents the mean composite score on the EVT-3 for the children with cochlear implants and matched control groups.

Table 2.1 PPVT – 5 Children with Cochlear Implants compared to Matched Control

	Children with cochlear implants		Matched control					
Score	**Mean**	***SD***	**Mean**	***SD***	**Difference**	**t value**	**p value**	**Standard difference**
PPVT–5	91.4	18.4	106.0	14.2	14.60	5.42	<.01	0.89

Table 2.2 EVT – 3 Children with Cochlear Implants compared to Matched Control

	Children with cochlear implants		Matched control					
Score	**Mean**	***SD***	**Mean**	***SD***	**Difference**	**t value**	**p value**	**Standard difference**
EVT–3	94.8	16.4	103.9	13.1	9.07	3.69	<.01	0.61

Discussion

This study provides data on the PPVT-5/EVT-3 performance of children with hearing loss who use cochlear implants. The clinical sample consists of children who use listening and spoken language as a preferred communication modality, and who utilize cochlear implants to access spoken language. Thorough inclusion and exclusion criteria were put in place to control for specific factors known to lead to variability in outcomes (e.g., additional diagnoses, primary communication mode, auditory access to language, and regular access to audiological and speech and language services).

With regard to performance on the PPVT-5 and EVT-3, the clinical group of children with cochlear implants obtained a mean composite score that was significantly lower than that obtained by the matched control group. It should be noted that the group mean for the control group was slightly higher than the population mean (i.e., 100), and while significantly lower, the cochlear implant group performed within the average range.

These results replicate previous research on cochlear implant users that demonstrate relatively lower scores on measures of receptive and expressive vocabulary. As noted previously, for children who have access to sound via assistive technology and for whom spoken English is their primary language, opportunities for incidental learning and exposure to English may differ in important ways from children in the normative sample. Further, these children may also have differed in their auditory access and/or the cognitive load required for these tasks.

While versions of the PPVT/EVT are commonly utilized measures for assessing the expressive and receptive vocabulary abilities of children with hearing loss, obtaining valid and useful assessment results from the administration of the PPVT-5/EVT-3 for this population is a complex issue that requires the consideration of numerous factors including examiner qualifications, test administration, communication preference, interpreter use, normative data, and reliability and validity issues.

According to the *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychology Association [APA], & National Council on Measurement in Education [NCME], 2014), ensuring fairness in testing requires consideration of test accessibility, which is the opportunity for test takers to demonstrate their true ability on the measured construct. In order to comply with this standard, examiners administering the PPVT-5/EVT-3 to children with hearing loss must be aware of the heterogeneity of this population, and the impact that relevant factors such as the age of onset of hearing loss, form(s) of communication, early language access, degree of hearing loss, timing and use of assistive technology, and co-morbid conditions can have on test performance. The current special group sample demonstrates that for children with cochlear implants who use listening and spoken English as a preferred communication modality, these factors significantly impact test performance even when controlling for other factors that can impact variability of outcomes, including comorbid conditions and lack of access to intervention services.

It is important to note that while the current sample did not include children with comorbid conditions, current estimates indicate that 40-52% of the deaf/hard-of-hearing population have at least one comorbid condition that impacts daily functioning (Chilosi et al., 2010; Davis, 2010; Gallaudet Research Institute, 2011, 2014). Further, it did not include children who do not utilize spoken English as their primary communication mode. For these groups of children with hearing loss, it is likely that factors in addition to those noted above for the current sample will influence their test results. Given the diversity of this population, there is not a single assessment approach that works for all children. Rather, examiner knowledge about, and careful consideration of the potential impact that each of the above factors has on the child's development, and test performance, is warranted.

As demonstrated by the results of this study, examiners are cautioned that the normative sample may not be an appropriate comparison group for children with hearing loss. While normative information for the general population is provided on the PPVT-5/EVT-3 to assist with the interpretation of scores, the PPVT-5/EVT-3 normative sample does not include individuals with hearing loss. Thus, comparability of scaled and standard scores for deaf and hard of hearing individuals with the normative population is limited, particularly if the scope of the referral reason is not to assess how a child compares to hearing peers.

Reliability and validity information regarding the use of the PPVT-5/EVT-3 with the all members of the deaf and hard of hearing population is not yet available. Differences in performance of children with hearing loss may be attributed to cultural and linguistic bias of test items, language delays, accommodations, or true differences in this group. Further studies are needed to provide evidence of reliability and validity for the use of the PPVT-5/EVT-3 with the deaf and hard of hearing population.

Efforts were taken during development of the PPVT-5/EVT-3 to simplify all verbatim test instructions to increase clarity of task demands, decreasing the potential confound of language on the overall administration. Confounds on the overall interpretation of results, however, may remain for children with hearing loss. For children who have access to sound via assistive technology and for whom spoken English is their primary language, opportunities for incidental learning and exposure to English may differ in important ways from children in the normative sample. When interpreting test results of the PPVT-5/EVT-3, a strong understanding of the child's overall language and communication is critical. Results should be understood and interpreted with an understanding of the language and cognitive capabilities of the child, and potential developmental impacts to language development.

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