Published in final edited form as:
Int J Audiol. 2009 May ; 48(5): 248–259.

Relationships Between Speech Perception Abilities and Language Skills in Young Children with Hearing Loss

Jean L. DesJardin
Canisius College

Amy S. Martinez, **Sophie E. Ambrose**, and **Laurie S. Eisenberg**
Children's Auditory Research and Evaluation (CARE) Center, House Ear Institute

Abstract

Objective of the study—The primary goal of this study was to examine relationships between scores obtained from measures of speech perception, standardized language, and spontaneous language samples in a group of young children with hearing loss (HL).

Subjects and Methods—Eighteen children with hearing loss (mean age = 4.3 years; range 2.4 – 6.3 years) and their mothers participated in this study. Speech perception was measured using the On-Line Imitative Test of Speech Pattern Contrast Perception (OLIMSPAC). Standardized language scores were obtained using the *Reynell Developmental Language Scales-III*. Number of word tokens, word types, and mean length of utterance (MLU) were extracted from the children's spontaneous language samples.

Results—Only one significant positive association emerged between OLIMSPAC and standardized language scores. In contrast, strong positive associations emerged between OLIMSPAC and all measures derived from children's spontaneous language samples (ranging from .77 to .90).

Conclusions—Assessment of speech perception, in combination with formal and informal language measures provides a more complete profile of the communication skills of young children with HL than each of these tests administered in isolation. Guidelines are offered for professionals who evaluate the communication abilities of young children with HL.

Keywords

speech perception; spontaneous language samples; spoken language; hearing loss

The ability to perceive the sounds of speech is the foundation for spoken language development. Over the past several years, a fairly large body of evidence has supported the notion that school-aged children with hearing loss (HL) who demonstrate superior speech perception skills also exhibit advanced spoken language abilities as assessed with standardized language measures (Blamey, Paatsch, Bow, Sarant, & Wales, 2002; Blamey, et al., 2001; Geers, Nicholas, & Sedey, 2003; Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007; Schorr, 2006; Tomblin, Spencer, Flock, Tyler, & Gantz, 1999). Unfortunately, at this time, similar studies in younger children are difficult to find, possibly due to a paucity of speech perception measures for children younger than 5 years of age and reduced vocabulary for this age group. With the focus on early identification and intervention (White, 2006; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), and cochlear implantation

Address for Correspondence: Jean L. DesJardin, 2001 Main Street, Buffalo, NY 14208, Phone: (716) 908-1328, jldesjardin@adelphia.net.

at 12 months and even younger (Waltzman & Roland, 2005; Colletti, Carner, Miorelli, Guida, Colletti, & Fiorino, 2005), many clinicians are assessing speech perception and language abilities of children with HL at very young ages. Appropriate measurement of auditory perceptual and linguistic development of this young population is particularly important because it guides early auditory prosthetic management and intervention.

Various instruments are presently available for assessing auditory and linguistic skills in very young children with HL. However, these instruments almost exclusively rely on parent report. Examples of these measures include, the *Ling Developmental Schedules (*Ling, 1977), the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) for children 1 to 3 years *(*Zimmermann-Phillips, Robbins, & Osberger, 2000), and the *Meaningful Auditory Integration Scale* (MAIS) for children 4 years and older (Robbins, Renshaw, & Berry, 1991). Both parent report and clinician-elicited measures are widely available for evaluating language. Examples of these two types of measures include the *SKI * HI Language Development Scale* (Watkins, 1979), the MacArthur-Bates Communicative Development Inventories (Fenson et al., 1992), the *Reynell Developmental Language Scales-III* (Reynell & Gruber, 1990), the *Preschool Language Scale-4* (Zimmerman, Steiner, & Pond, 2002) and the *Oral and Written Language Scales* (Carrow-Woolfolk, 1995). Although these language measures are standardized, there continues to be a least some heavy reliance on parental report and thus, many of these measures may have limitations for assessing early auditory and linguistic skills in young children with HL.

As a result of these limitations, supplementary approaches need to be considered. In terms of speech perception, formal assessment tools are being developed for infants and toddlers with HL (e.g., Dawson, Nott, Clark, & Cowan, 1998; Eisenberg, Martinez, & Boothroyd, 2007; Govaerts, Daemers, Yperman, De Beukelaer, De Saegher, & De Ceulaer, 2006). These assessment tools, which rely on elicitation techniques, may provide more reliable results and greater insight into a young child’s auditory perceptual development when compared to parent report alone. In particular, we have been developing tests specifically designed to assess speech pattern contrast perception in young children with HL (Eisenberg, et al., 2007). One such tool, The On-line-Imitative Test of Speech Pattern Contrast Perception or OLIMSPAC (Boothroyd, Eisenberg, & Martinez, 2005; Eisenberg, Martinez, & Boothroyd, 2003; Eisenberg, et al., 2007) has been developed to assess speech perception skills in children 3 years of age and older. This computerized measure assesses a young child’s ability to distinguish between phonologically significant contrasts (vowel height and place; consonant manner, voicing, and place) through the spoken imitation of nonsense syllables. The use of nonsense syllables enables the assessment of speech perception with minimal influence from higher-level linguistic cues. The test also is multi-modal in that it is typically assessed in the auditory-visual (AV) and auditory-only (AO) modalities.

The OLIMSPAC was developed as an indirect way to evaluate auditory perceptual capacity in children too young for higher level imitative tasks or multiple-choice tests. Development of the OLIMSPAC was based on the following premises: 1) imitation is an appropriate and natural activity for young children; 2) child’s imitations should reflect perception if their speech skills are acquired through hearing; and, 3) the ability to perceive phonologically significant contrasts is a necessary, though insufficient, condition for the development of more advanced spoken language skills. Early results with this test suggest that it is sensitive to degree of hearing loss as well as to differences in the perceptibility of phonetic contrasts (Eisenberg et al., 2003). For these reasons, the OLIMSPAC was selected as the speech perception measure in the present study.

In terms of language assessment, researchers and clinicians rely on a variety of standardized (criterion and norm-referenced) and non-standardized (language samples) measures that are important for assessing communication skills in young children with HL. Each tool provides necessary information to practitioners in order to assess a range of language skills (e.g., phonology, semantics, syntax), identify children's language strengths and weaknesses, and to monitor progress over time. While standardized language measures assess children's receptive language skills, expressive language skills, or both, measures of informal language rely on spontaneous language samples that primarily tap into a child's expressive language abilities (e.g., mean length of utterance or grammatical complexity and number of different words or index of semantic diversity).

Standardized language tests are norm-referenced and, when administered appropriately, provide a relatively quick means for comparing a child to age-matched hearing peers. There are some limitations, however, in the use of standardized language measures. Such tests are either clinician-elicited and thus provide a snapshot of a child's language abilities at the time of testing or they rely on parent report to get a more representative, albeit not necessarily more reliable, picture of the child's language abilities. Standardized language measures that rely at least partially on the clinician-eliciting test items rely on highly constrained situations. In these highly constrained situations, other factors beyond language ability, such as a child's attention, interest level, and motivation to interact with an examiner, may also contribute to language scores (Condouris, Meyer, & Tager-Flusberg, 2003). In such instances, the early interventionist or speech-language pathologist who performs the test may not be as familiar with the child as is the caregiver.

In addition, standardized language scores do not necessarily provide information that is specific enough to capture the emergence of expressive vocabulary and grammatical skills in younger children with HL. Over the first couple of years, a child may receive the same age-equivalent score on a standardized test, suggesting that the child with HL has not made any notable progress. For example, on the *Reynell Developmental Language Scale*s *III*, expressive raw scores range from 0 – 7 before an age equivalent score of one year, three months can be obtained. Yet, the same child may show considerable growth in communicative skills as demonstrated during a videotaped play-based interaction session.

In contrast, spontaneous language samples derived from parent-child interactions provide an index of a child's use of language in everyday informal situations (e.g., during free play or storybook interactions). A language sample has the advantage that it can be obtained during a natural interaction with a known caregiver and may be more representative of a child's language functioning within their daily environment (Hafer & Stredler-Brown, 2003). Such measures obtained from a spontaneous language sample (e.g., mean length of utterance or MLU, number of words, and number of different words) reveal the influence of the interaction among a child's individual linguistic knowledge, internal processing factors, and external processing constraints on verbal performance (Evans, 1996). Thus, skills gathered from a spontaneous language sample may show smaller incremental growth patterns that are not tapped on standardized language measures (Dunn, Flax, Sliwinski, & Aram, 1996).

Only a few studies have compared standardized and informal methods for measuring language. Bornstein and Haynes (1998) examined associations between measures derived from spontaneous language samples and standardized test scores in 184 typically developing 20-month-old hearing toddlers. Strong positive relationships were reported between receptive and expressive language scores from the *Reynell Developmental Language Scales* (RDLS), and the children's MLU and the number of different words obtained from mother-child free play interaction sessions. Similar findings were noted in typically developing hearing preschoolers (Ukrainetz & Blomquist, 2002) and young children with specific language delays (Condouris, et al., 2003). Hence, competencies from standardized tests appear to tap into the same underlying linguistic abilities derived from spontaneous language samples for hearing children. Although similar positive associations are evident in school-aged children with HL (Geers, et al., 2003; Tomblin, et al., 1999), less is known about the relationships between standardized language measures and measures derived from informal language samples for younger children with HL. Historically, clinicians have often relied on information gathered from parent interviews and checklists instead of from clinician-elicited, standardized measures or informal language samples.

To summarize, information obtained from speech perception and language assessments is important for monitoring and designing intervention plans for young children with HL. New clinical measures of speech perception that are not based on parent report are becoming available to address the needs for this population. Moreover, standardized language measures alone may not provide adequate information for clinicians to make important habilitation decisions for young children due to issues with parent report and the necessity of administration in highly constrained settings. Because we know that school-aged children with HL who demonstrate superior speech perception skills also exhibit advanced spoken language abilities, the current study was designed to investigate the relationships between speech perception skills and both standardized and informal measures of language with younger children with HL in order to provide a more in-depth understanding of children's developing auditory and language skills. The primary goals of this exploratory investigation were to address the following two questions: 1) What are the strengths of the relationships between children's speech perception and standardized language skills? and, 2) Are there associations between speech perception and measures derived from spontaneous language samples (MLU, number of word tokens, and number of word types) in young children with hearing loss?

Materials and Methods

Participants

Eighteen children with HL and their mothers participated in the study. Children and their mothers were recruited from the Children's Auditory Research and Evaluation Center (CARE) at the House Ear Institute in Los Angeles. Inclusion criteria included children between the ages of 2 ½ – 6 years of age, identified with hearing loss (mild – profound hearing range) with no known developmental cognitive or physical disability. Additionally, mothers and their children's primary language was spoken English in their home. As shown in Table 1, although a fairly diverse group, mothers were primarily Caucasian (66.7%), had some college education (88.9%) and came from middle to upper household income levels (83.4%).

The children consisted of eight females and ten males ranging in age from 29.0 – 75.0 months (M = 51.3 months). All children have bilateral sensorineural hearing loss; the mean 4-frequency pure tone average of better ear was 74.7 dB HL (range 27.5 – 115.0 dB HL). As displayed on Table 2, the average age of identification of hearing loss was 14.7 months, hearing aids fitted at approximately 19 months, with the length of time using their sensory device (hearing age) approximately 25 months. Seven out of the 18 children used a cochlear implant. The average age in which the children received their cochlear implant was 29.0 months with length of implant use ranging from 3 – 60 months. Parent report and the psychologist's notes from the children's clinical evaluation chart indicated no presence of additional disabilities, and nonverbal cognitive abilities were average to above average. The children's primary communication mode was auditory-oral.

Measure of Speech Pattern Contrast Perception

The On-line Imitative Test of Speech Pattern Contrast Perception (OLIMSPAC, Boothroyd, et al., 2005) is a computerized test that assesses the child's ability to perceive and produce phonologically significant contrasts through imitation of nonsense syllables. The administration of the OLIMSPAC is contingent upon the child having phonological knowledge and motor speech skills. The test is administered first in the AV and then AO modalities.

As shown in Figure 1, the speech stimulus is delivered through a sound field speaker stationed in a sound-attenuating booth at 0^0 azimuth. The visual stimulus consists of a woman saying the nonsense syllable, which is shown on a computer screen. The child, who is seated in the booth and looking at a computer monitor, verbally repeats into a microphone what he or she heard. The clinician administering the test is masked from hearing and seeing the target stimuli, thus making it more of an objective measure. After the child responds, the tester selects from the computer screen the stimulus that best approximates the child's utterance from a choice of eight alternatives. At the completion of the test, the results are automatically tabulated by the computer program and produced in graphic and numeric format for the AO and AV modalities (see Figure 2). The percent-correct scores are shown for the speech pattern contrasts of vowel height and place, and consonant manner, voicing, and place (front and rear positions). However, because the scores for each contrast are based on only eight binary trials, results for each contrast are essentially pass/fail. The composite score represents the average score across speech pattern contrasts and has more power because it is based on 48 binary trials. As a result, the composite score for the AV and AO modalities represent the speech perception dependent variables analyzed in this investigation.

Standardized Language Measure

The Reynell Developmental Language Scales-III (RDLS-III) (Reynell & Gruber, 1990) is designed to assess receptive and expressive language skills in children ages 1 year to 6 years, 11 months. As per the standardized procedure, the clinician uses real objects and pictures to elicit children's communicative language.

There are two primary scales derived from the *RDLS – III*: Verbal Comprehension and Expressive Language. The Verbal Comprehension scale taps into receptive language abilities. There are 67 items organized into 10 sections representing successively more developmentally advanced receptive language abilities. The earliest abilities involve verbal pre-concepts, indicated by infants' differential responsiveness to familiar words (e.g. "Mama") or phrases ("Mama's coming") spoken by the parent. The verbal comprehension scale also comprises sections such as attributes, locative relations, vocabulary and complex grammar, and inference. The Expressive Language scale also includes 67 items. There are three subscales tapping different aspects of early language development. The three subscales; structure, vocabulary, and content, are ordered developmentally with respect to the emergence of the language abilities they tap; however there is substantial overlap in the continuing development of each aspect of expressive language. The expressive language scale consists of such sections as verb phrases, auxiliaries, clausal elements, and inflections. Raw scores for both scales were converted to standard scores for data analyses.

Spontaneous Language Samples

Spontaneous language samples were obtained from the children while they interacted with their mother during a free play and storybook task. For a period of ten minutes, the mother and child were provided with two "Mr. Potato Head" fun activity kits (one kit designed to construct a female potato character and one kit designed to construct a male potato character). The Potato Head activity kits (Lerner, 1952) came with various toy pieces to engage the children in pretend play (e.g., scuba goggles, dress up shoes, various hats, fire person tools, earrings, various eyes and arms). Participants were asked to play and interact with each other as they would at home.

Following free play, the mother was provided with two storybooks, *What Next, Baby Bear!* (Murphy, 1983) and *Frog, Where Are You?* (Mayer, 1969). *What Next Baby Bear!* is a relatively short, colorfully illustrated book that contains a fantasy narrative about a little bear's preparations for a trip to the moon. *Frog Where Are You?* is a short wordless picture book about a pet frog who escapes from a jar, after which a sequence of misadventures befall a boy and his dog as they search for and eventually find the missing frog. Participants were asked to read or look at the two books, as they would typically do at home. The length of the storybook session varied from 5 – 10 minutes. Both books have been used in studies of children with normal hearing (Weizman & Snow, 2001; Berman & Slobin, 1994; Hoff-Ginsberg, 1997), children with hearing loss (DesJardin, 2007), and children with cochlear implants (DesJardin & Eisenberg, 2007).

Procedures

Informed consent was obtained before the experimental protocol was initiated. The accompanying mother completed a demographic questionnaire, providing information pertaining to their child's audiological and family background. All of the tests were administered individually in a comfortable room and frequent breaks were offered throughout the testing sessions.

Children were first assessed on the On-line Imitative Test of Speech Pattern Contrast Perception-Auditory Visual (OLIMSPAC-AV) and *Auditory Only* (OLIMSPAC-AO). Following the speech perception task, children's standardized language skills were assessed using the *Reynell Developmental Language Scales* (RDLS). Mothers and children were then videotaped for 20 minutes during a free play and two storybook interaction sessions using a digital camera (Canon Optura 30) hidden behind a one-way mirror. The mother wore a SHURE Brothers, Inc. Wireless Microphone (ID DD4L11) and was seated directly next to the child either in a chair or on the floor. An omni-directional boom microphone fixed to the wall of the room was also connected to the camera.

Data Preparation

Transcription and reliability—Videotaped data was transcribed in full using the Codes for the Human Analysis of Transcripts system (MacWhinney, 2000). To establish inter-rater reliability, transcripts were prepared by the first author and a speech-language pathologist from the CARE Center reviewed 20% of the videotaped data selected randomly. The calculation of word-by-word correspondence yielded a high reliability (90-97% agreement) between scores of the speech-language pathologist and those of the first author.

To ensure comparability of the language samples, 50 consecutive intelligible utterances were obtained from the samples, beginning with the free play context. If 50 usable utterances were not available from free play, utterances were taken from "*Frog Where Are You"* (Mayer, 1996) first, and then, if necessary, from *What Next Baby Bear!* (Murphy, 1983). These 50 utterances were used to calculate MLU, measured in morphemes (Brown, 1973), word tokens (total number of words) and word types (total number of different words). MLU, word tokens, and word types were selected because of their sensitivity in indicating developmental changes in children's language abilities and their wide use (Thal, DesJardin, & Eisenberg, 2007). Although research evidence suggests that an association between age and MLU is less reliable for MLU's greater than 3.0 (Condouris et al., 2003), it continues to be a valid predictor of syntactic complexity up to a MLU of approximately 4.0 (Snow & Willett, 1996). For this study, there were no children who exceeded a MLU of 4.0. Each measure of spontaneous speech (MLU, word tokens and word types) was calculated using the Computerized Language Analysis program (MacWhinney, 2000) and used in the data analyses.

Results

Means, standard deviations, minimum and maximum composite scores for the OLIMSPAC-AV and AO and each of the language measures are provided in Table 3. As shown in Table 3, children's receptive and expressive language age equivalents on standardized testing (RDLS) ranged from 24 months to 61 months for receptive language (M = 41.9 months) and from 26 months to 61 months for expressive language (M = 40.7 months). Although children's language age equivalents are lower than their chronological age (M = 51.3 months), their abilities are higher when referenced to the children's age since sensory device fitting (M = 25.0 months).

Correlation Analysis

Spearman's rank-order correlations (<.05) were first conducted to examine the strength of the relationships between OLIMSPAC composite scores (AV and AO) and children's demographic variables. Significant positive associations emerged between AV and AO and child age (AV; $r = 0.69$, $p < .01$; AO; $r = 0.47$, $p < .05$), age of identification (AV; $r = 0.58$, $p < .05$; AO; $r = 0.36$, $p < .05$), and age at sensory device fitting (AV; $r = 0.61$, $p < .01$; AO; $r = 0.35$, $p < .05$). No significant relationships emerged, however, between AV and AO and the HL group's length of sensory device use (AV; $r = 0.14$, p = ns; AO; r −0.03, p = ns) or 4-frequency pure-tone average (AV; $r = -0.42$, p = ns; AO; $r = -0.33$, p = ns).

Relationships between Speech Pattern Contrast Perception and Standardized Language Measures

Spearman's rank-order correlations (< .05) were conducted to examine the strength of the associations between OLIMSPAC composite scores (AV and AO) and children's receptive and expressive standardized language scores. As displayed in Table 4, only one significant positive relationship emerged between OLIMSPAC AV and AO and children's standard language scores. A positive association was noted between OLIMSPAC-AO and children's receptive language ($r = 0.52$, $p = <.05$).

Relationships between Speech Pattern Contrast Perception and Informal Language Measures

Spearman's rank-order correlations were conducted to examine the relationships between OLIMSPAC composite scores (AV and AO) and measures derived from the spontaneous language samples (see Table 4). Cohen (1988) recommends that correlation coefficients of .10, .30, and .50 be interpreted as small, medium, and large, respectively, and this scale has been used in other behavioral research (e.g., Thal, et al., 2007). The relationships between OLIMSPAC-AV and AO composite scores and the informal language measures (MLU, word tokens, word types) were considerably stronger than those with the standard language scores. As illustrated in Figure 3, statistically significant associations were evident between OLIMSPAC-AO and children's MLU ($r = 0.86$; $p < .01$), word tokens ($r = 0.87$; $p < .01$), and word types ($r = 0.90$; $p < .01$).

Discussion

The primary aim of the present study was to investigate the relationships between children's speech perception skills and both standardized and non-standardized language competencies in a group of young children with HL. Our first research question explored the relationships between children's speech perception and standardized language skills. Contrary to studies investigating the positive associations between speech perception and spoken language outcomes in school-aged children with HL as measured by standardized tests (e.g., Blamey, et al., 2002; Blamey, et al., 2001; Geers, et al., 2003; Schorr, 2006), only one positive relationship was evident between children's ability to perceive and produce various speech patterns and their receptive and expressive standardized language skills for this group of young preschool to early school-age children with HL. It is unclear at this time why these relationships were not significant and requires further study.

Our second research question investigated the relationships between children's speech perception and non-standardized language skills. Strong positive associations were found between children's ability to perceive various sounds as measured by the OLIMSPAC and all measures derived from the children's language samples. For young children with HL, the ability to accurately perceive various speech pattern contrasts presumably can reflect the child's every day language competencies. Further investigations will be important to explore the predictive factors of this particular auditory perception measure on children's lexical and grammatical language development over time, and if indeed, children's developed language skills predict better auditory performance (Blamey et al., 2002).

For young children with HL, age of identification and time of receiving their hearing aids were also important to their speech perception outcomes. Findings from this study suggest that early diagnosis and fitting of sensory aids relate to higher speech perception abilities. Consistent with findings from a previous study (Eisenberg et al., 2003), pure-tone average was also generally related to speech perception skills, although these correlations did not reach statistical significance. This may likely be due to the small number of subjects in this study and also to the fact that the children with profound hearing loss were cochlear implant users. The cochlear implant has been shown to improve speech perception performance in children with profound HL to the level of a child with severe HL (e.g., Boothroyd & Boothroyd-Turner, 2002; Eisenberg, Kirk, Martinez, Ying, & Miyamoto, 2004).

These findings are important for several reasons. The data presented confirm the utility of the OLIMSPAC paired with language sampling for assessing overall emerging auditory and language skills in young children with HL. Given that these measures individually provide separate pieces of information, pediatric audiologists and speech and language pathologists may feel more confident as they continue to use these measures for on-going follow-up as they formulate important decisions about a child's early habilitation. The strong positive correlations found between the scores on the OLIMSPAC and measures derived from language sampling in the children with HL suggest that their auditory capabilities reflect, to a certain extent, how well they use perceived speech patterns in formulating words and sentences in informal every day interactions with their caregivers.

Although findings from this study offer professionals a better understanding of the utility of the OLIMSPAC, important limitations must be addressed. First the OLIMSPAC measures not only children's speech perception, but also their abilities to produce certain speech sounds. Thus, a weakness of this test is the assumption that less than perfect imitation may represent a deficit in perception rather than motor speech skills. One way to tackle this problem is by assessing imitative performance using other inputs, such as lipreading or, in the case of older children, writing or finger spelling. We used lipreading in this study because of the young age of these children. In view of the fact that performance is typically higher in the AV modality relative to the AO modality, evidence is provided to suggest that motor-speech skill is not the only limiting factor in the AO performance scores. It would be of interest to repeat this study with the newer emerging clinical tests of speech perception.

Implications for Clinicians

Pediatric audiologists and speech-language pathologists are presently assessing emerging auditory and language abilities at much younger ages in children with HL because of newborn hearing screening programs. Limited standardized tools are available to evaluate young children's speech perception abilities. The tools that are available rely heavily on parental report. It is essential that new techniques be developed in order to assess the benefit of sensory aids in a population of very young children with HL. With new measures of speech perception, clinicians will be able to better assess and track the development of auditory perceptual abilities and, as a result, make the necessary adjustments to a child's audiological intervention plan to improve better outcome performance. Future studies will assess whether the OLIMSPAC or other newer tests will effectively allow for this assessment and tracking of auditory perceptual abilities.

Spontaneous language sampling also offers more to clinicians regarding children's language competencies. While standardized language measures often elicit test items that are non-communicative and decontextualized, language sampling elicits children's language within a relaxed context (e.g., play or book reading interaction with their caregivers). Children are more apt to be attentive and motivated to demonstrate their language abilities within this comfortable context (Condouris, et al., 2003). Furthermore, standardized language scores do not necessarily provide information that is specific enough to capture the emergence of expressive vocabulary and grammatical skills in younger children with HL. These findings provide further support for the use of a more comprehensive approach to assessing communication skills than is presently being widely practiced.

The link between early speech perception abilities and everyday language patterns is critical for later educational outcomes for children with HL. Because the ability to perceive the sounds of speech is the foundation for language development, we can assume that a child who performs well on tasks required to understand and produce various sound patterns, will most likely be able to produce those sounds in various words and sentences during daily conversational interactions. Conversely, a discrepancy between a child's performance on a speech perception task and their spoken language skills demonstrated during a parent-child interaction session may warrant some caution. For instance, if a child performs well on a particular speech perception task with 90% confidence, yet is unable to produce those same sound patterns within words and sentences in every day conversations, there may be other factors that need to be addressed (e.g., additional disabilities, phonological processing deficits). As has been noted in the literature on young children with NH, the ability to identify a child's language strengths and challenges at this early stage of development may be instrumental in preventing later and more serious language delays (Goffman & Leonard, 2000).

Spontaneous language samples have the potential to provide clinicians with more in-depth information about a child's emerging language skills. Although analysis of language samples can be tedious and labor intensive (Hux, Morris-Friehe, & Sanger, 1993), measures derived from an informal language sample provide detailed information often not available from standardized language tests. During formal testing situations, children may feel uncomfortable with a test administrator that he or she does not know and, therefore, are less likely to demonstrate their true abilities. Language skills demonstrated during natural interactions with their primary caregivers may reflect children's language growth better than formal tests in the early stages of language development (Goffman & Leonard, 2000). Moreover, information gathered from spontaneous language samples can help guide families and professionals as they work together in tracking children's growing expressive language skills and in developing appropriate language goals for the Individualized Family Service Plan (IFSP) or Individualized Education Plan (IEP).

Conclusion

Comprehensive assessment is essential for obtaining accurate information in defining a child's speech perception and spoken language abilities. Tools such as the OLIMSPAC are starting to emerge that are able to tap into young children's early speech perception capabilities. The use of these types of measures paired with informal language assessments may better represent children's early emerging language skills when compared to standardized language assessments alone. The information obtained from such assessment tools is extremely useful to professionals working with families of young children with HL in the early stages post sensory device fitting. Such information can provide clinicians and parents with more precise information regarding their child's audiological management and communication skills.

Acknowledgments

This study was made possible by a grant from the National Institute on Deafness and Other Communication Disorders (NIDCD) of the National Institutes of Health (grant #R01DC006238). A very special thank you is expressed to the parents and children who participated in this study. We are grateful to Donna Thal, Ph.D. for providing expertise and guidance in videotape analysis.

References

Berman, R.; Slobin, D. Relating Events in Narrative: A crosslinguistic Developmental Study. Erlbaum; Hillsdale, NJ: 1994.

Blamey PJ, Paatsch LE, Bow CP, Sarant JZ, Wales RJ. A critical level of hearing for speech perception in children. Acoustical Society of America. 2002; 3(1):18–23.

Blamey PJ, Sarant JZ, Paatsch LE, Barry JG, Bow CP, Wales RJ, Wright M, Psarros C, Rattigan K, Tooher R. Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. Journal of Speech, Language, and Hearing Research. 2001; 44:256–272.

Boothroyd A, Boothroyd-Turner D. Postimplantation audition and educational attainment in children with prelingually acquired profound deafness. Annals of Otology, Rhinology, & Laryngology. 2002; 111(Suppl. 189):79–84.

Boothroyd, A.; Eisenberg, LS.; Martinez, A. OLIMSPAC, Version 3.1d. House Ear Institute; Los Angeles, CA: 2005.

Bornstein MH, Haynes OM. Vocabulary competence in early childhood: Measurement, latent construct, and predictive validity. Child Development. 1998; 69:654–671. [PubMed: 9680678]

Carrow Carrow-Woolfolk, E. Oral and Written Language Scales. American Guidance Service, Inc.; Circle Pines, MN: 1995.

Cohen, J. Statistical power analysis for the behavioral sciences. 2nded.. Erlbaum; Hillsdale, NJ: 1988.

Colletti V, Carner M, Miorelli V, Guida M, Colletti L, Fiorino FG. Cochlear implantation at under 12 months: Report on 10 patients. Laryngoscope. 2005; 115:445–459. [PubMed: 15744155]

Condouris K, Meyer E, Tager-Flusberg. The relationships between standardized measures of language and measures of spontaneous speech in children with autism. American Journal of Speech and Language Pathology. 2003; 12(3):349–358.

Dawson PW, Nott PE, Clark GM, Cowan RSC. A modification of play audiometry to assess speech discrimination ability in severe-profoundly deaf 2-to-4 year old children. Ear and Hearing. 1998; 19:371–384. [PubMed: 9796646]

DesJardin JL, Eisenberg LS. Maternal contributions: Supporting language development in young children with cochlear implants. Ear & Hearing. 2007; 28:456–469. [PubMed: 17609609]

Dunn M, Flax J, Sliwinski M, Aram D. The use of spontaneous language measures as criteria for identifying children with specific language impairment: An attempt to reconcile clinical and research incongruence. Journal of Speech and Hearing Research. 1996; 39:643–654. [PubMed: 8783141]

Eisenberg LS, Kirk KI, Martinez AS, Ying EA, Miyamoto RT. Communication abilities of children with aided residual hearing: Comparison with cochlear implant users. Archives of Otolaryngology—Head & Neck Surgery. 2004; 130:563–569. [PubMed: 15148177]

Eisenberg LS, Martinez AS, Boothroyd A. Auditory-visual and auditory-only perception of phonetic contrasts in children. The Volta Review. 2003; 103:327–346.

Eisenberg LS, Martinez AS, Boothroyd A. Assessing auditory capabilities in young children. International Journal of Pediatric Otorhinolaryngology. 2007; 71:1339–1350. [PubMed: 17604127]

Evans J. SLI subgroups: Interaction between discourse constraints and morphological deficits. Journal of Speech and Hearing Research. 1996; 39:655–660. [PubMed: 8783142]

Fenson, L.; Dale, PS.; Reznick, JS.; Thal, D.; Bates, E.; Hartung, JP.; Pethick, S.; Reilly, JS. The MacArthur-Bates Communicative Development Inventories. Paul H. Brookes; 1992.

Geers AE, Nicholas JG, Sedey AL. Language skills of children with early cochlear implantation. Ear & Hearing. 2003; 24:46S–58S. [PubMed: 12612480]

Goffman L, Leonard J. Growth of language skills in preschool children with specific language impairment: Implications for assessment and intervention. American Journal of Speech-Language Pathology. 2000; 9:151–161.

Govaerts PJ, Daemers K, Yperman M, De Beukelaer C, De Saegher G, De Ceulaer G. Auditory speech sounds evaluation (ASSE): A new test to assess detection, discrimination and identification in hearing impairment. Cochlear Implants International. 2006; 7:92–106. [PubMed: 18792377]

Hafer, JC.; Stredler-Brown, A. Family-centered developmental assessment. In: Bodner-Johnson, B.; Sass-Lehrer, M., editors. The Young Deaf or Hard of Hearing Child: A Family-Centered Approach to Early Education. Paul H. Brookes Publishing Co.; Baltimore: Maryland: 2003. p. 140-141.

Hoff-Ginsberg, E. Language Development. Brooks/Cole Publishing Company; Pacific Grove, CA: 1997.

Hux K, Morris-Friehe M, Sanger DD. Language sampling practices: A survey of nine states. Language, Speech, and Hearing Services in Schools. 1993; 24:84–91.

Lerner, G. Mr. Potato Head Fun Activity Kits. HASBRO Company; 1952.

Ling, AH. Schedules of development in audition, speech, language, and communication for hearing-impaired infants and their parents. The Alexander Graham Bell Association for the Deaf, Inc.; Washington, D.C.: 1977.

MacWhinney, B. The CHIDES project: Tools for analyzing talk. Earlbaum; Hillsdale, NJ: 2000.

Mayer, M. Frog, where are you?. Dial Books for Young Readers; New York: 1969.

Moeller MP, Tomblin JB, Yoshinaga-Itano C, Connor CM, Jerger S. Current state of knowledge: Language and literacy of children with hearing impairment. Ear and Hearing. 2007; 28:740–753. [PubMed: 17982362]

Murphy, J. What next, baby bear!. Dial Books for Young Readers; New York: 1983.

Reynell, J.; Gruber, CP. Reynell Developmental Language Scales. U.S. Edition. Western Psychological Services; Los Angeles, CA: 1990.

Robbins AM, Renshaw JJ, Berry SW. Evaluating meaningful auditory integration in profoundly hearing-impaired children. American Journal of Otology. 1991; 12:144–150. [PubMed: 2069175]

Schorr EA. Early cochlear implant experience and emotional functioning during childhood: Loneliness in middle and late childhood. The Volta Review. 2006; 106(3):365–380.

Snow CE, Willett JB. Predictors of MLU: Semantic and morphological developments. First Language. 1996; 16:243–259.

Thal D, DesJardin JL, Eisenberg LS. Validity of the MacArthur-Bates Communicative Development Inventories for measuring language abilities in children with cochlear implants. American Journal of Speech-Language Pathology. 2007; 16:54–64. [PubMed: 17329675]

Tomblin BJ, Spencer L, Flock S, Tyler R, Gantz B. A comparison of language acievement in children with cochlear implants and children using hearing aids. Journal of Speech, Language, and Hearing Research. 1999; 42:497–511.

Ukranienetz TA, Blomquist C. The criterion validity of four vocabulary tests compared with a language sample. Child Language Teaching and Therapy. 2002; 18:59–78.

Waltzman S, Roland T. Cochlear implantation in children younger than 12 months. Pediatrics. 2005; 116(4):487–493.

Watkins, S. SHI*HI Language Development Scale. SKI*HI Institute; Logan, Utah: 1979.

Weizman Z, Snow C. Lexical input as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. Developmental Psychology. 2001; 37:265–279. [PubMed: 11269394]

White KR. Early intervention for children with permanent hearing loss: Finishing the EHDI Revolution. The Volta Review. 2006; 106(3):237–258.

Yoshinago-Itano C, Sedey AL, Coulter DK, Mehl AL. Language of early and later-identified children with hearing loss. Pediatrics. 1998; 102:1161–1171. [PubMed: 9794949]

Zimmerman, IL.; Steiner, VG.; Pond, RE. Preschool Language Scale Fourth Edition: Examiner's Manual. The Psychological Corporation; San Antonio, TX: 2002.

Zimmerman-Phillips S, Robbins AM, Osberger MJ. Assessing cochear implant benefit in very young children. The Annals of Otology, Rhinology, & Laryngology. 2000; (Supplement 185):42–43.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

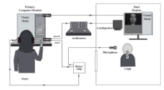

Figure 1.
Block diagram of the OLIMSPAC test set-up.

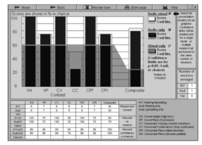

Figure 2.
Graphic display of OLIMSPAC results for a hearing aid user.

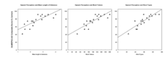

Figure 3.
Relationships between children's speech perception composite scores and MLU, word tokens and word types.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 1

Demographic characteristics of mothers.

Demographic Characteristics	Mothers (n = 18)
Age	Mean 38.0 years (*SD*; 4.14) range 32 – 45 years
Education level	
High School	2 (11.1%)
Some College	7 (38.9%)
College graduate	8 (44.4%)
Post-graduate	1 (5.6%)
Household income	
<$15,000	1 (5.6%)
$15,000 - $29,999	0 (0.0%)
$30,000 - $49,999	2 (11.0%)
$50,000 - $74,999	3 (16.7%)
$75,000 - $100,000	7 (38.9%)
>$100,000	5 (27.8%)
Primary home language	
English	18 (100.0%)
Ethnicity	
Caucasian	12 (66.7%)
Latino	4 (22.2%)
Asian American	1 (5.6%)
Other	1 (5.6%)

Table 2

Demographic characteristics of children (n = 18).

Demographic Characteristics	Mean (*SD*)
Age at testing	4.3 years (16.3) range 2.4 – 6.3 years
Gender	
Boys	10 (55.6%)
Girls	8 (44.4%)
Sensory device	
Hearing aid	11 (68.8%)
Cochlear implant	7 (31.3%)
Age at identification	14.7 months (*14.5*) range newborn – 42 months
Age at hearing aids	19.3 months (*17.9*) range 1 – 68 months
Age at cochlear implant (N = 7)	28.8 months (*16.3*) range 12 – 42 months
Length of hearing aid use	25.0 months (*13.4*) range 3 – 48 months
Length of cochlear implant use	26.1 months (*11.6*) range 9 – 36 months
Unaided 4-frequency pure-tone average	74.7 dB HL (30.9) range 27.5 – 115.0 dB HL

Table 3

Summary of scores for children's speech perception and language measures.

Measures	Mean (*SD*; range)
Speech perception (OLIMSPAC)	
AV scores	79.3 (*16.7*; 46 – 100)
	n = 3 (ceiling score)
AO scores	75.6 (*14.9*; 42 – 92)
	n = 0 (ceiling score)
Standardized language (RDLS)	
Receptive standard score	90.1 (*21.4*; <63 – 125)
Expressive standard score	87.9 (*17.4*; <63 – 122)
Receptive language age	41.9 months (*13.3*; 24 – 61)
Expressive language age	40.7 months (*12.3*; 26 – 61)
Measures from spontaneous language samples:	
Mean length of utterance (MLU)	2.5 (*.79*; 1.37 – 4.0)
Number of word-tokens	124.4 (*42.9*; 45 – 210)
Number of word-types	59.7 (*18.3*; 24 – 94)

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 4

Relationships between children's speech perception scores (OLIMSPAC AV and AO) and language measures.

Language Measures	Speech perception composite scores	
	OLIMSPAC – AV	**OLIMSPAC - AO**
RDLS receptive standard score	.36	.52*
RDLS receptive language age	.69**	.62**
RDLS expressive standard score	.02	.06
RDLS expressive language age	.60**	.46
Mean length of utterance	.80**	.86**
Number of word tokens	.84**	.87**
Number of word types	.77**	.90**

OLIMSPAC - AV = On – line Imitative Test of Speech Pattern Contrast Perception - Auditory Visual

OLIMSPAC - AO = On – line Imitative Test of Speech Pattern Contrast Perception – Auditory Oral

* $p < .05$

** $p < .01$

Table 5

Summary of regression models for children's MLU.

Step-wise Regression Models	**R**	**R^2**	**Change in R^2**	**Significance in F Change**
Model 1:				
Child age	.695	.482		.001
OLIMSPAC AV	.853	.728	.245	.002
OLIMSPAC AO	.908	.824	.096	.015
Predictors for Final Model	**β**	**p**		
Child age	0.454	0.008		
OLIMSPAC AV	0.042	0.871		
OLIMSPAC AO	0.597	0.015		