Current State of Knowledge: Language and Literacy of Children with Hearing Impairment

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The purpose of this paper is to provide a review of past and current research regarding language and literacy development in children with mild to severe hearing impairment. A related goal is to identify gaps in the empirical literature and suggest future research directions. Included in the language development review are studies of semantics (vocabulary, novel word learning, and conceptual categories), morphology, and syntax. The literacy section begins by considering dimensions of literacy and the ways in which hearing impairment may influence them. It is followed by a discussion of existing evidence on reading and writing, and highlights key constructs that need to be addressed for a comprehensive understanding of literacy in these children.

(Ear & Hearing 2007;28;740–753)

Over the past decade, universal newborn hearing screening programs and advancements in sensory devices have improved the prospects for children with all degrees of hearing impairment (HI). These innovations have led to a resurgence of interest in research focused on various subpopulations of children with HI. This momentum is partly guided by practical interests, especially the need to strengthen the evidence base that guides the management of these children. Empirical study of this group also holds theoretical interest, as it allows researchers to explore the influences of auditory perception and auditory experience in foundational aspects of language and literacy development. In the 1970s and early 1980s, Dr. Julia Davis and colleagues at the University of Iowa called attention to the paucity of research on outcomes in children with mild to severe HI. As this review will show, there are still many gaps in the literature in relation to this group. Because of newborn hearing screening, we have the opportunity to close these gaps through prospective research, beginning in infancy. At this time, considerable efforts are being expended to identify these children early and to provide optimal hearing and communication services. Although there is increasing evidence that early-identified infants with HI progress in speech and language at rates that exceed later-identified peers (Apuzzo & Yoshinaga-Itano, 1995; Calderon, 2000; Calderon & Naidu, 2000; Kennedy, McCann, Campbell, et al., 2006; Moeller, 2000; Robinshaw, 1995; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), there is need for further research documenting outcomes of this group of children. In the subsequent sections we will review the literature regarding the status of children with mild to severe HI and identify directions for future research efforts.

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Language Abilities of Children with Mild-Severe Hearing Impairment

In contrast to the large body of research on children with severe-profound HI, systematic studies of language development in children with mild-severe HI are limited in number and scope. This section focuses on spoken language for specific domains (vocabulary, novel word learning/semantics, morphology, and syntax) that appear most consistently in the literature. Studies of narrative development, pragmatics, discourse participation, and verbal reasoning are relatively rare. Given the relevance of these latter areas to literacy and socialization, they represent research priorities. The language section of this review ends with a brief consideration of the need for studies of the population of children with mild, high frequency, or unilateral HI.

Many of the studies reviewed involve participants with a history of late access to interventions/amplification. Children with late access differ from children with normal hearing (NH) in the quality and extent of their auditory-linguistic experiences. Studies often report wide variability in the performance outcomes for children with HI, and contradictory findings about possible sources of individual differences. For example, there is a lack of consensus about the influence of degree of HI on language outcomes. This question is of practical interest in determining who needs what type of intervention (i.e., do children with mild and unilateral HI need intervention?). However, degree of HI rarely acts alone in contributing to development. It may, in fact, interact with a host of other variables (e.g., family involvement, behavioral issues, consistency of amplification use, noise levels in day care settings, additional disabilities, quality of intervention, receipt of cochlear implants) to influence outcomes in various directions. Multivariate studies on large groups of children, along with carefully executed longitudinal studies, are needed to understand individual differences and guide intervention practices.

Vocabulary Development

Several studies have examined the spoken language performance of children with mild to severe HI on standardized measures of vocabulary. The focus of this review is on studies involving children with mild to severe HI who use spoken language. In some cases, studies that included children with mild to profound HI are reviewed, because the majority of the subjects fell in the mild-severe range. These studies are noted to aid interpretation. A table in the Appendix summarizes eight studies that measured vocabulary outcomes. Across these studies, divergent conclusions were reached regarding the status of vocabulary in school-aged students with HI. Some suggest that even the mildest degree of HI will delay vocabulary development (Davis, Elfenbein, Schum, & Bentler, 1986; Davis, Shepard, Stelmachowicz, & Gorga, 1981; Wake, Hughes, Poulakis, Collins, & Rikards, 2004). Others conclude that many school-aged children with mild-moderate HI perform comparably to age-matched peers with NH (Gilbertson & Kamhi, 1995; Plapinger & Sikora, 1995; Wolgemuth, Kamhi, & Lee, 1998). A longitudinal study conducted in Germany (Kiese-Himmel & Reeh, 2006) suggested that preschool children with mild to severe HI make larger gains in vocabulary than children with greater degrees of HI; 2 of 5 children with mild HI and 2 of 11 with moderate HI developed age-appropriate vocabulary skills.

Gilbertson and Kamhi (1995) reported a bimodal distribution in the vocabulary scores of 20 school-aged students with mild-moderate HI. Specifically, high performers (n 10) scored in the low average range on the PPVT (Mean Standard Scores 88.3), whereas low performers (n 10) scored significantly below average (Mean SS 58.1). Because the low performers had difficulty on a variety of language/learning tasks, it was postulated that these children had Specific Language Impairments (SLI) in addition to hearing loss. However, it is unclear whether children in this study varied on background variables (e.g., age of interventions/amplification). In a later study (Moeller, 2000), intervention history and family involvement were found to contribute uniquely to vocabulary outcomes in 5-yr-old children with HI. In addition, quality of intervention has been linked to age-appropriate language performance in children with HI (Nittrouer & Burton, 2003). It is challenging to interpret data on low performers without control of potentially interacting background variables. Clearly, prospective studies are needed to better understand factors that influence: (1) individual differences and (2) long-term outcomes, including the role of specific interventions, so that atypical learning behaviors may be identified and addressed. Epidemiological studies are needed to verify the incidence and characterize types of secondary disabilities in children with mild to severe HI (estimated to be approximately 35% in children with mild to profound HI per Gallaudet Research Institute, 2005).

Two recent studies identified delays in the development of early receptive and expressive vocabulary in young children with HI, some of whom were studied longitudinally from infancy (Mayne, Yoshinaga-Itano, & Sedey, 2000; Mayne, Yoshinaga-Itano, Sedey, & Carey, 2000). These studies used a maternal report measure (MacArthur-Bates Communicative Development Inventory, MCDI; Fenson, Dale, Reznick, et al., 1993) to examine vocabulary size at several ages in large groups (168 and 113, respectively) compared with norms for infants with NH. In both studies, slightly more than 50% of the participants had HIs in the mild to severe range, and early identification was common. The results suggested that the average performers (those at the 50th percentile for HI) were significantly delayed in both receptive and expressive vocabulary compared with age-matched children with NH. Acceleration of the rate of expressive vocabulary learning was observed in the young children with HI after 25 mo of age (approximately 7 mo later than observed in toddlers with NH).

Prospective studies are needed to understand the sources and nature of vocabulary delays in early-identified infants with HI. Moeller et al. are conducting longitudinal studies of early word learning in infants with normal and impaired hearing. Their recent findings (Moeller, et al., 2007a,b) suggest that phonetic and phonological delays influence vocabulary growth in young children with HI (subjects were mild-moderate to profound). Future research needs to examine perceptual and cognitive processes that underlie symbolic development in young children with HI. Strategies used in cognitive psychology with young children could be harnessed to address a variety of unanswered questions. For example, how do these children use multimodal processing strategies to extract relevant properties from the input? What cues do they attend to in forming representations? What caregiver strategies optimize perceptual and symbolic learning? How does the infant's growing social understanding inform word learning? How do children progress from gesture to symbol? Are there ways to optimize sensory devices to ease demands on auditory attention and allow overhearing as an access route for learning? In summary, further research is needed to enhance our understanding of the impact of limitations in auditory experience (e.g., because of sensory loss, noise, reverberation, distance, and time without amplification) on young children's ability to perceive, abstract, store, and retrieve word representations.

Novel Word Learning and Semantic Development

There also is value in shifting the research focus away from measures of vocabulary size toward studies designed to understand word learning processes, including semantic category development. A small set of studies have addressed these topics in children with mild to severe HI. Novel word learning paradigms (where children are introduced to unfamiliar, often nonsense words) are used in developmental research to explore the cognitive-linguistic processes underlying children's learning. Gilbertson and Kamhi (1995) explored novel word learning strategies in a group of 20 school-aged children with mild to severe HI compared with a group of students with NH. Students were introduced to four novel words of varying length and phonological complexity. Half of the children with HI performed comparably to NH peers on all experimental measures. The other half demonstrated difficulty learning phonologically complex words and required significantly more trials to learn the target words than peers with NH or HI. The lower performers also scored less well on measures of language and phonological processing. The authors concluded that word learning delays were related to the children's difficulties encoding, storing, and retrieving phonological information.

Strategy use was explored in a study of novel word learning in young children with HI (Lederberg, Prezbindowski, & Spencer, 2000). Of the 19 children (ages, 3;2 to 6;10) involved this study, 12 had HI in the moderate-severe range. Two experiments explored rapid word learning (sometimes called "fast mapping") and novel word mapping strategies. Rapid word learning refers to children's ability to learn at least a partial word representation after minimal exposure (1 or 2 times). Results of this study showed that children with HI were delayed in developing rapid word learning skills, but eventually acquired words rapidly in explicit naming contexts (e.g., direct teaching). However, they reached this stage before they were able to use novel mapping strategies. When children use a novel mapping strategy, they infer that a new word spoken to them refers to a novel (unfamiliar) object, as opposed to objects in the environment they already know. For example, suppose a child sees four objects on the table (car, truck, train, and skateboard) and he already knows car, truck, and train. When an adult refers to the skateboard, the child infers that the adult must mean the unfamiliar object in the set of four. This novel mapping strategy aids children in matching the word with the intended object of reference. Previous studies suggest that vocabulary size, not age, is related to children's use of the novel mapping strategy (Mervis & Bertrand, 1994), and it is often observed in children 2 yr of age with NH (Golinkoff, Hirsh-Pasek, Bailey, & Wegner, 1992; Graham, Poulin-Dubois, & Baker, 1998). Lederberg et al. (2000) found that children with HI acquired the strategy after they developed a vocabulary of about 200 words, a time point that was delayed relative to children with NH. The authors concluded that children with HI show delayed but typical patterns of word learning strategies, and that strategy use is closely tied to vocabulary development.

Novel word learning paradigms also have been used to explore the impact of auditory access/amplification strategies on vocabulary learning in children with normal and impaired hearing (Pittman, Lewis, Hoover, & Stelmachowicz, 2005; Stelmachowicz, Pittman, Hoover, & Lewis, 2004). Stelmachowicz et al. (2004) examined rapid word learning of eight nonsense words presented in a story context to 20 children with NH and 11 children with moderate to moderately severe HI (ages, 6 to 9 yr). Results indicated that the children with NH learned and retained more words than the children with HI. Predictor variables were the children's vocabulary size, number of exposures (more was better), and presentation level (louder was better for both groups). In a related study, Pittman et al. (2005) examined the effects of providing a broader frequency bandwidth on word learning in 60 children with NH and 37 children with moderate HI (ages, 5 to 14 yr). It was reasoned that enhanced perceptual access in the high-frequency range might support word learning processes. PPVT scores for the children with HI were lower than those of the children with NH, although only five children with HI were 1 SD below the mean. Notably, the children with HI learned novel words more slowly than children with NH; their performance was related to their vocabulary scores. The extended bandwidth condition did not significantly improve word learning for either group. The results suggest that low average PPVT scores do not necessarily ensure a novel word learning rate comparable to age-matched peers with NH.

A few investigators have explored the potential impact of childhood HI on language processing in real time (Jerger, Lai, & Marchman, 2002) and the organization of semantic information into categories (Jerger, Damian, Tye-Murray, Dougherty, Mehta, & Spence, 2006). It is known that category formation can help children to organize and generalize knowledge, make inferences and remember what was learned. Recently, Jerger et al. (2006) used a speeded category verification task to explore the development of conceptual knowledge in 30 children with mild to severe HI (28/30 80 dB HL; M 51 dB HL), compared with children with NH (from Jerger & Damian, 2005). The children with HI ranged in age from 5 to 15 yr, and they varied in ages of identification/amplification. All were successfully mainstreamed and used spoken language. Children were given a category (i.e., clothing) and they were asked to say "yes" if pictured objects were members of the clothing category. Four types of pictures were used: (1) typical category members (pants), (2) atypical members (glove), (3) related, but out of category objects (necklace), and (4) unrelated out of category objects (soup). These contrasts were presented to explore the influence of typicality (prototypical examples are easier to access) and relatedness (related objects like necklaces that share the property "worn on the body" take longer to process) on the latency of children's responses. Results indicated that children with HI performed like children with NH (showing both the typicality and relatedness effects). Specifically, the children with HI appropriately structured conceptual categories and understood the semantic properties of categories. However, performance decreased as degree of HI increased, suggesting that these effects may be related to the quality and quantity of auditory input. They also reasoned that when children have well developed auditory skills, less cognitive effort may be required to process the input. They found a relationship between age at ID/amplification/education and task performance. It was suggested that early-identified children may have the advantages of more auditory-language experience and more mature cognitive-linguistic knowledge, which may optimize semantic learning.

Jerger et al. (2002) explored the impact of semantically related auditory distractors on picture naming by children with NH and those with moderate HI. They asked 30 children with HI and 129 children with NH to name pictures while attempting to ignore semantically related auditory word distractors. As an example, children attempted to label a picture of cat while they heard the word dog. In this condition, two lexical representations sharing semantic properties (e.g., household pet, four legs) are highly activated at the same time and the child must select the correct alternative (e.g., purrs) and inhibit the incorrect alternative (e.g., barks). In this situation, the related lexical representations are assumed to compete for control of the response, slowing picture-naming times relative to unrelated distractors, termed "semantic interference." Results indicated that children with HI show semantic interference similar to NH peers, suggesting that children with HI appreciate within-category semantic properties. However, results also indicated the children with HI have prolonged lexical access, suggesting subtle effects of HI on lexical retrieval processes. This study and Jerger et al. (2006) used different methods but came to the same conclusions about the parallels in semantic development in children with NH and HI.

This set of studies on semantic and perceptual foundations of word learning has theoretical importance regarding the role of language experience in establishing perceptual learning mechanisms that facilitate language development. However, there are many gaps in the extant literature. There is a need for research related to word and conceptual learning strategies in early-identified infants and young children with HI. Prospective analyses are needed to examine relationships among input quantity and quality, vocabulary size, cognitive strategies, and shifts in word learning strategies in these children. Most studies examine children's learning in ideal, quiet conditions. There is a need for better understanding of the impact of degraded listening conditions (e.g., distance, noise, reverberation) on children's ability to extract relevant semantic cues from the input. The influence of multimodal perceptual and cognitive strategies on emerging semantic categories also should be examined in this group. In addition, studies are needed to explore the impact of HI on children's development of abstract concepts in the preschool years (e.g., understanding of emotion concepts, mental state terms, and temporal relations) and the influence of these concepts on narrative participation. Innovative research paradigms, such as those used by Jerger et al. (2002, 2006) provide needed insight about semantic categories, and also seem to be sensitive to effects of age of identification and degree of hearing loss. Further research of this nature would be beneficial.

Morphological Development

There is evidence from several studies that children with mild to severe HI experience delays in morphological development. McGuckian and Henry (2007) recently reported on a comprehensive study of morphological development in children with moderate HI. This study examined the production accuracy of grammatical morphemes (e.g., endings on

TABLE 1. Accuracy levels ordered from highest to lowest in children with HI and NH (From McGuckian & Henry, 2007)

Order of Accuracy: HI	% Correct (SD)	Order of Accuracy: NH	% Correct (SD)
Progressive -ing (running)	97 (4.3)	Possessive -s	97.1 (4.4)
Prepositions (in, on)	94.1 (8.1)	Plural -s	96.0 (3.6)
Articles (a, the)	92.7 (7.9)	Progressive -ing	94.6 (2.8)
Plural (cat/cats)	88.3 (7.0)	Prepositions	94.3 (8.1)
Copula (She's nice)	88.0 (6.4)	Copula	89.4 (6.9)
Irregular past (run/ran)	76.1 (16.5)	Articles	79.5 (18.3)
Auxiliary (He's been here)	75.1 (19.0)	Auxiliary	77.1 (18.5)
Third singular -s (She talks)	58.5 (21.0)	Third singular -s	69.3 (20.4)
Past -ed (They walked)	53.6 (23.4)	Past -ed	55.0 (23.4)
Possessive –s (Mary's ball)	32.3 (16.4)	Irregular past	42.2 (22.8)

words that mark rules: plural cat/cats or verb tense I go/he goes) in 10 children with moderate HI (mean age of 7;4 yr) and 10 children with NH (mean age of 3;2 yr). The two groups were matched on mean length of utterance (MLU), a global measure of grammatical complexity. The mean better ear pure-tone average (PTA) for the children with HI was 56.4 dB HL (SD 8.17) and the mean age at hearing aid (HA) fitting was 29 mo (SD 12.37). Both groups of children were seen for five data collection sessions, involving elicitation procedures and spontaneous language samples. All children with HI demonstrated the ability to produce word final consonants (/t/, /d/, /s/, and /z/) in single morpheme contexts (cat; bus) before participation. Groups were compared in terms of accuracy of morpheme production in obligatory contexts, as well as the order of accuracy across the 10 forms studied. Children with HI did not demonstrate a simple delay in morphological development; rather the order of accuracy for various rules differed from children with NH. Table 1 summarizes the results of these comparisons. The order of development for the children with HI was similar to that observed in second language learners, leading the authors to suggest that access to input/auditory experience may play a role in delayed morphological development. The morphemes that were most challenging for the children with HI (third singular -s, past -ed, and possessive -s,) are those that are reported to occur least frequently in the input (Brown, 1973).

Evidence from audiological studies suggests that limited perceptual access to fricatives may influence morphological development. Stelmachowicz, Pittman, Hoover, and Lewis (2001) documented that the restricted bandwidth of HAs limits the audibility of /s/, especially for female and child talkers. They concluded that children who wear HAs may hear a final /s/ when spoken by a male, but not by a child or female talker. Such perceptual access differences could result in inconsistent input about morphological rules. In a second study, aided perception of the plural -s was examined in 36 children with normal hearing (3 to 5 yr of age) and 40 children with moderate hearing losses (5 to 13 yr of age; Mean PTA 52 db HL, SD 15; Stelmachowicz, Pittman, Hoover, & Lewis, 2002). Results indicated that children with NH improved in their perception of plural morphemes with age. In contrast, children with HI showed highly variable performance (both high and low levels of accuracy were seen across all ages). Importantly, plural test items spoken by a female talker were the least accurately perceived by the children with HI. Given that children are often with female caregivers, these talker effects may play a role in the consistency of the child's access to the input. Perceptual access to morphological markers also may be influenced by distortions induced by noise, reverberation, and distance. Furthermore, longitudinal research reported by Moeller et al. (2007a) documented delays in fricative production in young children with HI (even those with moderate HI), suggesting phonological influences on morphological production in this group. More research in this area may foster improvements in hearing technologies so that perceptual access may be enhanced.

Only two other studies specifically investigated morphological development in children with mild or moderate HI. Brown (1984) compared morphological production accuracy (from spontaneous language samples) in 10 children of age 9 yr with moderate HI who were matched on MLU to 10 children of age 4 yr with NH. Because elicitation procedures were not used, only five morphemes were used frequently enough to allow for statistical analysis (progressive -ing, preposition "in", articles, copula and auxiliary "be"). No significant differences were found between these groups in morpheme use, and they concluded that the pattern was one of delay in the children with HI. However, this study was limited in scope and the language sampling procedures did not yield a comprehensive analysis of morphemes. Norbury, Bishop, and Briscoe (2001) examined verb morphology (third person singular -s, regular and irregular past tense) in 19 children with mild-moderate HI (ages, 5 to 10 yr), compared with 14 children with

SLI (ages, 7 to 10 yr) and two control groups with NH (age-matched and vocabulary-matched). Key findings were that the children with HI performed better than the children with SLI, and on average, comparably to controls. However, six of the youngest children with HI showed difficulty with third person singular -s and past tense markers. The results suggested that mild-moderate HI may delay the mastery of verb morphology. There is need for additional research examining morphological development in young children with HI who have early access to amplification. It will be important to determine ways to optimize perceptual access through improvements in sensory devices. In addition, intervention studies might be designed to examine specific strategies for supporting children in mastering morphological rules.

Syntactic Development

Relatively few studies have explored syntactic development in the spoken language of children with mild to severe HI. Elfenbein, Hardin-Jones, and Davis (1994) analyzed spontaneous language samples and grammatical completion skills of 40 school-age students (5 to 18 yr of age) who were sorted into three groups by degree of HI: (A) 15–43 dB HL, (B) 45–60 dB HL, and (C) 63–80 dB HL. They were compared with a group of 16 children with NH (ages, 5 to 18 yr). Findings suggested that the frequency of grammatical errors was related to degree of hearing loss, but the error rate of children with mild-severe HI did not approach the severity typically observed in deaf students. Error rates were higher in the children with HI than in NH, and most frequent errors involved: complex syntax, verb structures (e.g., omissions of main, copular, auxiliary, or modal verbs), bound morphemes, and pronouns. Overall patterns of development, although delayed, were similar to children with NH, with the exception of verb omissions.

Comprehension and production of advanced syntax is known to support discourse participation, reading comprehension, and social reasoning (Astington & Jenkins, 1999; de Villiers & de Villiers, 2000). Because there were so few articles that examined complex syntax in students with mild-severe HI, a few studies with a broader range of hearing levels are included in this review. Friedman and Szterman (2006) examined understanding and use of phrasal movement (relative clauses, topicalized sentences) in 20 Hebrew speaking, orally trained students with moderate to profound HI. Fourteen students used bilateral HAs; the six children with profound HI used cochlear implants. The children were 7 to 9 yr of age and their performance was compared with a control group of students with NH. Students with HI showed deficits in comprehension and production of sentences requiring noun phrase movement. Noun phrase movement refers to repositioning a phrasal element from its original place to another position in the sentence (e.g., "This is the girl that the boy liked" contains noun phrase movement originating from "The boy liked that girl"). Early intervention was associated with better performance outcomes on these tasks.

Future studies are needed to explore how students with HI integrate linguistic domains to serve their communicative purposes. For example, speakers will typically use relative clauses when they infer the need to provide background information to the listener. Object complements (He knew that the girl already had a ride, so he just left) are used to reference knowledge states and are important for social reasoning (de Villiers & de Villiers, 2000). A key issue is to examine how students with HI use advanced syntax to serve communicative and literacy purposes.

Two studies suggested that subgroups of children with HI perform comparably to age-matched peers with NH in syntax comprehension. Briscoe, Bishop, and Norbury (2001) tested 19 children with mild-to-moderate HI (5 to 10 yr of age) on the Test of Reception of Grammar among other measures. They found that the children with HI, on average, performed liked 20 age-matched peers with NH. Nittrouer and Burton (2003) found that children with a history of intensive oral training (Mean PTA 58 dB HL, 2 with Cochlear Implants) performed comparably to school-aged peers with NH on a test of complex syntax understanding. Children with HI with a history of general special education services demonstrated delays in grammar understanding. The authors suggest that intervention quality may contribute to language development outcomes. A third study (Gilbertson & Kamhi, 1995) documented that 20 children with mild-to-moderate HI (Mean age 9 yr) performed comparably to younger children with NH (Mean age 6;5 yr) on a standardized test of grammar understanding (Test of Language Development). Notably, grammar understanding was significantly associated with novel word learning skills (r 0.77).

There seems to be a need for research that takes an integrated approach to examining receptive and expressive syntactic development in children with HI. An integrated approach might consider how grammatical devices are used for social communication purposes. For example, how do children with HI use grammatical skills for effective self-expression at the narrative and discourse levels? Do children with mild to severe hearing levels master object complements in a way that allows them to explain events with reference to mental states? Do children use grammatical devices to appropriately provide background information to listeners? Do children use temporal cohesion as a way to organize stories they tell?

Ongoing Research Needs

A growing body of recent research focuses on the impact of permanent mild, high frequency and unilateral hearing losses (termed "MSNHL") on language development. It is beyond the scope of the current review to provide a comprehensive discussion of these areas. However, it is important to keep in mind that mild hearing loss may be missed by current universal newborn hearing screening protocols (Norton, Gorga, Widen, et al., 2000). This means that children with mild HI may continue to be more difficult to enroll in studies in infancy, delaying our understanding of the impact of MSNHL in early stages. These children represent an important group of research participants, given that there is lack of agreement about the need for interventions (sensory devices, educational programs) for this population of children.

Research suggests that many children with unilateral hearing loss (approximately 27–35%) are at risk for language and academic difficulty (Bess, Dodd-Murphy, & Parker, 1998; Culbertson & Gilbert, 1986; Dancer, Burl, & Waters, 1995; Johnson, 2005; Oyler, Oyler, and Matkin, 1988; Sedey, Stredler-Brown, & Carpenter, 2006). Given that these children now are identified through newborn hearing screening, there is a need for prospective, longitudinal study of their outcomes to guide interventions. For further information on the outcomes of this group, a critical review of recent findings on unilateral HI may be found in Lieu (2004), and a comprehensive summary of outcomes on children with MSNHL is available online from Dr. Danielle Ross at www. cdc.gov/ncbddd/ehdi/unilateralhi.htm (Ross, 2006).

Literacy and Academic Achievement Outcomes in Children with Mild-Severe HI

Within our culture and increasingly world wide, a critical developmental expectation of children is that they become literate and that they succeed in acquiring at least basic academic skills. The impact of severe to profound HI on the development of literacy and academic skills has been shown to be substantial (Goetzinger & Rousey, 1957; Pintner & Patterson, 1916; Traxler, 2000). In keeping with much of the literature regarding children who have mild to severe HI, surprisingly little is known about their literacy and academic achievement. The literature concerned with the listening and speaking abilities of these children suggest that as a group they are at some risk for poor development of spoken language. This review will summarize the small number of studies that have been conducted, but before this summary, a brief consideration of what constitutes literacy and reading skills will be provided. In so doing, we will construct a framework for relating HI in children with reading development and the place of spoken language in this causal chain.

Reading and Literacy

We will define literacy as a sociocultural activity of meaning construction using text. Thus, writing and the appreciation of various genres of written forms is part of literacy. Reading in this case is a component skill that contributes to literacy by use of orthographic information provided by the text to construct a meaning interpretation of the author's intent. When viewed in this manner, the research on literacy in children with HI is primarily a literature on their reading ability.

We just stated that reading is a skill that uses orthographic information. That is, reading involves the use of visual information. Why then, would we hypothesize that children with HI have difficulty with a visual task such as reading? Indeed, scholars and physicians have long advocated that individual differences in reading, particularly those of dyslexia, are rooted in visual problems (Everatt, Bradshaw, & Hibbard, 1999; Hinshelwood, 1917; Willows, Kruk, & Corcos, 1993). Although it would be unwise to ignore the contribution of the visual system to reading, most of the research on poor readers in general, and dyslexics in particular, point to poor oral language abilities as the basis for reading difficulty.

There are two important aspects of language that in turn influence two principal components of reading. The first concerns the development of phonological processing abilities. Phonological processing is typically measured by tasks that require the child to analyze spoken word forms into constituent parts, repeat strings of syllables that form novel words, or rapidly name common words. Common to these tasks is thought to be robust, good quality phononological representations (Godfrey, Syrdal-Lasky, Millay, & Knox, 1981; Snowling & Hulme, 1989; Torgesen, Wagner, Simmons, & Laughon, 1990; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). Development of such phonological skills has been found to be particularly important to the development of word decoding. Decoding is the basic reading skill that allows the reader to use orthographic information to recognize the word with respect to its phonological properties and hence its meaning. The second aspect of language important to reading consists of lexical, sentence and discourse processes that are involved in listening and speaking. This aspect of language is necessary for the child to comprehend the meaning of the passages once word decoding has been accomplished.

From this perspective, it is easy to see how poor hearing during the preschool years could very easily affect later reading development. To the extent that the auditory limitation affects the child's development of robust phonological representations, we might expect to find difficulties in the development of decoding abilities. The integrity of these phonological skills is not typically demonstrated in ordinary communication activities. Deficits in these skills require tasks that place demands on the phonological system and therefore, unless they have been examined, we may not know whether they have been affected by the hearing loss. The child who experiences HI during the preschool years is also vulnerable to reading problems that arise from weaker development of vocabulary, sentence, and discourse skills, and these could affect reading comprehension even if phonological skills are intact. We have seen that these skills are at least in jeopardy in those children with mild to severe HI. Finally, accumulating evidence shows that, unlike language, reading skills must be explicitly taught (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001), including the emergent literacy skills learned as preschoolers (Senechal & LeFevre, 2002). Thus, mild to severe HI may present barriers to the child's learning from explicit instruction because of: 1) poorer ability to profit from the language of instruction due to their weaker language skills, and 2) missed opportunities to perceive oral instruction due to hearing loss.

Reading Skills in Children with Mild to Severe HI

Most of the literature available to address our questions concerning the nature of literacy and reading skills in these children provides a general view of reading and reading related achievement. In fact, to gain some insight into the general reading abilities of these children we will need to expand our consideration of reading to indicators of general academic performance and assessment of opportunities to learn at home and in the classroom. One of the first studies to provide any information concerning reading in children with mild to severe HI was that of Kodman (1963). A survey of 100 children between 7 and 17 yr of age who had HI in the mild to severe range was conducted and among the measures reported was that of academic achievement. These children were found to be one grade level below their actual grade placement on standardized achievement tests administered by their schools and more than two grades below their chronological age expectations. Kodman noted that although 65% of these children had losses of greater than 30 dB HL, only 35% had HAs.

More than a decade later, Davis (1977) published "Our Forgotten Children: Hard-of Hearing Pupils in the Schools." This book called for the provision of services to children with mild to severe HI in the school setting and the need for research that examined the educational problems of these children. A decade later, Blair and colleagues (Blair, Peterson, & Viehweg, 1985) studied 24 children with mild HI (20–45 dB HL better ear pure tone average thresholds) who were in 1st through 4th grades and compared their academic achievement on the Iowa Tests of Basic Skills with a comparable group of classmates. The sample sizes were small in each case and no inferential statistics were performed. The Iowa Tests of Basic Skills provided scores for vocabulary, reading comprehension, mathematic concepts, mathematic problem solving, total math, and total composite. Across these six measures and the four grades, the scores of the children with HI were always poorer than controls with NH. Additionally, the difference in achievement between HI and NH controls increased across the grades. The eight 4th-grade children with HI were nearly two grades below the control group, however, they were reading at their grade level according to the test norms. The authors concluded that the mild HI appeared to result in cumulating academic disparity in the children with HI. Soon after this, Davis and colleagues (Davis, et al., 1986) reported on the academic achievement of 40 school-age children and adolescents with largely mild to severe HI. These children were grouped into a group with PTAs of 44 dB or less (group A), 45 to 60 dB (group B), and greater than 60 dB (group C). The aided speech reception thresholds for these three groups were 21.3, 26.29, and 31.30, respectively. Unlike the earlier Kodman study, these children were viewed as good HA users although current standards of audiological care might dispute this given the absence of real ear measures for HA fitting and the fact that we do not know when these HAs were fit. The fact that aided hearing levels were even reported stands out in this study. Reading comprehension was measured via the Peabody Individual Achievement Test. The mean reading quotients for the three groups were all below the average score for the normative sample on the Peabody Individual Achievement Test and these means declined as a function of the severity of the hearing loss, although this difference was not significant. The absence of a severity effect may be reflective of the effect of HAs on language-related bases of reading. The average reading quotient for the group as a whole was significantly different from the normative group. Not surprisingly, their reading comprehension ability was strongly correlated with their receptive vocabulary as measured by the Peabody Picture Vocabulary Test (r 0.61) and their verbal IQ as measured by the Wechsler Intelligence Scale for Children-R (r 0.76). Parent report on the Child Behavior Checklist with regard to academic performance indicated that the parents viewed their children with HI as doing much less well in school than the parents who contributed to the norms of this report form.

Another decade passed before more information that related to reading in children with mild to severe HI emerged. Recall that subtle phonological processing skills have been found to be predictive of word reading and in particular decoding of words that conform to English orthography. As noted earlier, Gilbertson and Kamhi (1995) compared a group of children with HI with a control group of children with NH on measures of word learning and language, but also included measures of nonword repetition and rapid naming performance. Nonword repetition was poorer for the children with HI than NH controls; no difference was found for rapid naming. Nonword repetition has often been viewed as a sensitive indicator of phonological processing. Thus, these results could suggest that early HI can have an impact on phonological processing development. Rapid naming tasks have been found to be predictive of reading performance and some have suggested that this task also involves phonological processing (Wagner, Torgeson, & Rashotte, 1994). Denckla and Cutting (1999) have argued that rapid naming, however, contributes uniquely to word reading by reflecting basic cognitive speed of processing and visual verbal processing. Children with deficits in both phonological processing and rapid naming would have a double deficit that would increase the likelihood of a reading impairment. The data from Gilbertson and Kamhi (1995) might imply that children with HI are, as a group, susceptible to a single deficit in phonological processing and that these children have normal abilities with regard to speed of processing and visual verbal abilities.

During this time, interest in the outcomes of children with mild HI was stimulated by research on minimal HI conducted by Bess and colleagues (Bess, et al., 1998). Within this research they reported on the academic achievement of a group of 137 children with MSNHL who had been identified via a population sample of children in grades 3, 6, and 9 along with 400 classmates with normal hearing. Minimal sensorineural HI consisted of children with unilateral losses (20 dB HL in one ear), high frequency losses (25 dB HL loses above 2K), and bilateral losses between 20 and 40 dB HL. Of these children, 12 had bilateral mild HI. These children with mild HI were significantly poorer in third grade than the children with NH sampled in this study on all standardized measures of academic performance using the Comprehensive Test of Basic Skills. Word reading and decoding skills were particularly discrepant from the children with NH at this grade level. Thus, in this respect, the prediction that aspects of reading that depend on phonological skills would be particularly vulnerable in these children is given some support. Unlike the Blair study, there did not seem to be evidence of compounding of these problems as the children progressed in school. No differences in reading were found at the 6th and 9th grade levels. However, rates of grade retention were much greater for students with HI, which may explain, in part, the smaller differences later in school. Evidence of a more wide spread reading problem was suggested by data from the Screening Instrument for Targeting Educational Risk, which is a teacher rating form that provides information on academic, communication, and behavioral performance. Odds of academic failure or marginal performance were greater across grades for the children with minimal HI than children with NH, and this difference was marginally significant (p 0.06).

The number of studies on reading in children with mild to severe HI remained sparse as we entered the 21st century. What little data there was supported the view that reading skills were depressed even among children with mild HI. This general consensus changed with a paper by Briscoe and colleagues (Briscoe, et al., 2001) that examined the phonological processing skills and reading achievement of children between the ages of 5 and 11 yr with and without mild to severe HI. Much of this study was motivated by an interest in comparing children with SLI with children who had mild to severe HI to test whether SLI might be caused by low level perceptual deficits. Within the course of this study, several reading and reading-related measures were obtained. The reading measures spanned nonword reading, real word identification, and reading comprehension. Additionally, measures of phonological awareness and nonword repetition were obtained. Therefore, this study provided the first broad look at reading and reading-related skills in this population.

Somewhat surprisingly, the children with HI were not different on any of the reading tasks than the age mates with NH nor were their scores outside the range of normal performance for the normative population. In contrast, the children with HI were poorer on the phonological awareness and nonword repetition tasks than the NH controls, but not on measures of digit repetition. Both nonword repetition and phonological awareness measures are viewed as measures of phonological processing. Digit span also is often sensitive to poor phonological abilities; however, this task uses familiar words that can provide compensation via lexical support. The presence of poor phonological processing and yet unimpaired reading is unexpected within the common understanding of language-reading relationships. Given the standard notion of a strong relationship between phonological processing and nonword reading in particular, we would expect that deficits should have appeared particularly in reading tasks that emphasized decoding of unfamiliar words.

Similar results to the Briscoe study were also reported by Gibbs (2004). In this study, primary grade children with HI were found to be reading at levels comparable to the hearing norms when given a real word reading task that provided text with picture support. Because this test provided support, a second group of HI children and NH controls was tested on word reading in isolation and on phonological memory and phonological awareness measures. Again, the HI children read at comparable levels as their age mates. The author also concluded that the children with HI were more comparable to younger NH children on the phonological measures although these HI children were also not significantly different from their age mates. Not surprisingly, phonological awareness performance was correlated to hearing status in the HI group, but phonological awareness was not correlated with reading performance.

Very recently, Most and colleagues (Most, Aram, & Andorn, 2006) examined the literacy abilities of kindergarten children with and without HI. The children with HI were either placed in their own neighborhood classroom (individual integration; II) or were placed in a classroom with a mixture of children with HI and NH (group integration: GI). The average hearing loss of the II group was 61 dB HL (SD, 28.5) whereas it was 86 dB HL (SD, 24.5) for the GI children. Thus, the individual integration group (II) was comprised of primarily children with moderate to severe HI and the GI group may be viewed as children who were largely severe to profound. For our purposes, the II group representing mainly children with moderate HI is of interest. This II group was found to be significantly poorer on word recognition, phonological awareness, letter identification, and orthographic knowledge than the group with NH. For the first time in the literature we see a measure of literacy that extends beyond reading itself. A measure of word writing ability was obtained that ranged from the developmental quality of the graphic characters to spelling. On this measure the group of II children did not differ from the controls with NH.

When taken as a whole, children with HI seem to be at risk for poorer reading achievement and these children seem to be particularly at risk for poor phonological processing skills, which are generally regarded as important support for the acquisition of decoding skills. Clearly, the magnitude of this risk is not as high as it is in children with more severe HI and many children with HI are normal readers. Of particular interest are the findings of the Briscoe et al. (2001) and Gibbs (2004) studies. Both of these studies found no evidence for poorer reading in children with HI. Both of these studies were conducted fairly recently, and therefore, we may be seeing the effects of new technology and new practices. Additionally, both these studies were conducted in the United Kingdom. Perhaps there are health and education service practices that account for the difference between these studies and those that have come out of the United States.

Summary and Directions for Literacy and Reading Development Studies

A fundamental precondition to the provision of health and special education services is evidence that individuals with a certain characteristic that may limit the functional status of these individuals actually does so. The data available to date provide some weight in the direction of there being depressed reading performance in children with mild to severe HI. To date, this seems to be the extent of our knowledge. The studies that have contributed to this literature are limited in number and the sample sizes were often quite small. Rarely was information concerning the nature of the actual functional hearing of these children reported. Unaided thresholds are not likely to be a good indicator of the nature and extent of auditory function in these children. Indices of audibility and of HA use may be needed. As children are being identified earlier, the age of identification and HA fitting is also an important variable. Family background and literacy practices, along with preschool opportunities and later classroom-based instruction, would also be useful particularly in demonstrating that controls are comparable to the sample with HI. As suggested throughout, a much wider perspective on literacy is also needed. Within reading, the component skills need to be well measured. It will be important to determine how well these children do with comprehension of material that spans genre and in particular expository text that forms the basis of a great deal of higher grade reading material. Literacy beyond reading as a skill needs to be considered along with writing samples. Finally, we will need to be prepared to conduct studies that capture and enlighten us with regard to individual differences and the impact of specific literacy instruction strategies and accommodations (Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007).

Conclusions

Today's clinicians and researchers are faced with a new generation of children with mild to severe HI. These children typically have access to early identification, enhanced hearing technologies, and early intervention. Consequently, there is need for a new generation of research that will strengthen the evidence base and guide practices. To address many of the relevant research questions about children with mild to severe HI, we need to recruit larger, more representative samples. This may require the cooperation of multiple research centers working toward mutual goals. In addition, we need to carefully characterize the factors that lead to individual differences in this group of children, which will require prospective longitudinal and cross-sectional studies with experimental research designs. In both arenas, there is need for careful refinement and/or development of our research tools and measures. We have argued that the research focus should broaden, to include multidimensional definitions of language and literacy. In addition, consideration needs to be given to the ways in which language foundations are established to support children's literacy and literate thinking processes.

Acknowledgments

The authors appreciate the helpful input from Dr. Pat Stelmachowicz and two anonymous reviewers on earlier versions of this manuscript. This work was supported, in part, by the National Institute on Deafness and Other Communication Disorders, grant R01DC006681 to Boys Town National Research Hospital, grant DC-00421 to the University of Texas at Dallas, and grant P50 DC00242 to the University of Iowa.

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APPENDIX

Studies including vocabulary	Sample	Better ear pure tone ave range (dB HL)	Age at HA/type	Vocabulary measure(s)	Main conclusions
Davis, et al. (1981)	N 72 (SNHL/ mixed group) Ages: 5–12 yr	25 dB–80dB	Not reported Only 40% binaural users	Retrospective records review; PPVT scores	Vocabulary skills for HI NH for all categories of severity (including mild) Children with HI 50 dB outperform children with HI 50 dB Extent of delay increases with age
Davis, Elfenbein, Schum & Bentler (1986)	N 40 Ages: 5–18 yr	44 dB (N 16) 45–60 dB (N 15) 63–80 dB (N 9)	M 5.15 yr 38 HA users 19 binaural	PPVT-R	Even mildest hearing losses can result in vocabulary delays; only 6/40 children scored above age norms PPVT Mean Standard Scores: Mild 83, Moderate 80, Mod-Severe 73
Wake, Hughes, Poulakis, Collins & Rikards (2004)	N 86 Ages: 7–8 yr	26–40 dB (N 19) 41–60 dB (N 27) 61–80 dB (N 15) 81 dB (N 25) Population Study	M 23.5 mo (14.8) 12 with CIs	PPVT, Form B	HI group scored 1.3–1.7 SDs below NH population mean, HI M 85; 40% of SS 70 Subgroup Mean Standard Scores: Mild 87.5 (3.5), Moderate 85.7 (2.7) Severe 71.0 (3.6)
Gilbertson & Kamhi (1995)	HI N 20 Ages: 7;9–10;0 NH N 20 Ages, 5;1–9;7	HI group: M 42 dB (21.16)	Not reported 18 wore HAs; 2 walkman receivers	PPVT-R EOWPVT	Bimodal distribution into high and low subgroups of performers with HI PPVT SS: high group 88.3 (22.26), low group 58.1 (9.83) EOWPUT SS: high group 101.5 (25.61), low group 78.4 (6.64) Low group described as "language-impaired children" with a hearing loss
Plapinger & Sikora, (1995)	N 12 Ages: 7–13 yr	25–67 dB (and one subject at 93 dB)	Not reported 11/12 used binaural HAs	PPVT-R EOWPVT	Students with HI, on average, scored within normal limits on both vocabulary tests PPVT SS: 94.2 (16.8) Range 54–114 EOWPVT SS: 110.4 (15.3), Range, 78–132
Wolgemuth, Kamhi & Lee (1998)	HI N 13 Ages: 10;0–15;7 NH N 12 Ages: 5;1–9;7	HI group: 44.53 (16.6)	Not reported 12/13 used HAs	WNL on PPVT-R M 98.46 (range, 85–116); Metaphor competence tasks	HI matched to NH on vocabulary also within normal limits in metaphor competence
Moeller (2000)	N 112 Ages: 5;0–5;11	65 participants mild to severe SNHL M 77.8 (25–120 dB)	M 20 mo (range, 3 mo–4;6 yr)	PPVT-R	ID 24 mo of age were 1.0–1.5 SD below norms at 5 yr of age; Family involvement (35.2%) and age of enrollment (11.4%) contributed significantly to variance in outcomes
Kiese-Himmel & Reeh (2006)	N 27, 2;0–4;4 yr (time 1); 3;6–6;0 (time 3)	20 dB–90 dB	M 32.3 mo. All binaural	Kaufman Assessment Battery (vocabulary subtest)	Average performance significantly NH; best gains over time in mild & moderate groups 2/5 mild & 2/11moderate WNL by time 3