Developmental Psychology
2013, Vol. 49, No. 1, 15–30

0012-1649/12/$12.00 DOI: 10.1037/a0029558

Language and Literacy Development of Deaf and Hard-of-Hearing Children: Successes and Challenges

Amy R. Lederberg
Georgia State University

Brenda Schick
University of Colorado–Boulder

Patricia E. Spencer
Rockport, Texas

Childhood hearing loss presents challenges to language development, especially spoken language. In this article, we review existing literature on deaf and hard-of-hearing (DHH) children's patterns and trajectories of language as well as development of theory of mind and literacy. Individual trajectories vary significantly, reflecting access to early identification/intervention, advanced technologies (e.g., cochlear implants), and perceptually accessible language models. DHH children develop sign language in a similar manner as hearing children develop spoken language, provided they are in a language-rich environment. This occurs naturally for DHH children of deaf parents, who constitute 5% of the deaf population. For DHH children of hearing parents, sign language development depends on the age that they are exposed to a perceptually accessible 1st language as well as the richness of input. Most DHH children are born to hearing families who have spoken language as a goal, and such development is now feasible for many children. Some DHH children develop spoken language in bilingual (sign-spoken language) contexts. For the majority of DHH children, spoken language development occurs in either auditory-only contexts or with sign supports. Although developmental trajectories of DHH children with hearing parents have improved with early identification and appropriate interventions, the majority of children are still delayed compared with hearing children. These DHH children show particular weaknesses in the development of grammar. Language deficits and differences have cascading effects in language-related areas of development, such as theory of mind and literacy development.

Keywords: deaf, hearing loss, cochlear implants, language development, literacy

In this article, we discuss developmental trajectories of children with hearing loss. Language development has long been recognized as the most important area affected by hearing loss. Although the relation between the degree of hearing loss and an individual's access to spoken language is complex, hearing loss is often categorized as mild, moderate, moderately-severe, severe, severe-profound, or profound. Children with milder losses typically achieve access to speech when fitted with hearing aids; however, any degree of loss raises the risk of language delays (Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007). Even with amplification, children with moderately-severe to profound hearing loss do not perceive speech in the same way as hearing people (Harkins & Bakke, 2011). Our focus in this article is on this latter group, who make up about half the population of children with hearing loss in the United States (Gallaudet Research Institute, 2008). Except for those with deaf parents, these children require significant intervention to acquire language. Cognitive and academic domains are also affected, as evidenced by problems in the development of theory of mind and literacy.

The issue of whether deaf and hard-of-hearing (DHH) children's developmental trajectory is more appropriately considered merely different or actually deficient compared to that of hearing children remains controversial (Lane, Hoffmeister, & Behan, 1996). Children with hearing loss are classified by school and medical systems as having a disability or hearing *impairment*. However, many deaf people reject the notion that decreased hearing or the inability to acquire spoken language is a disability and dislike the term *impairment* because it suggests that hearing loss is a deficiency. Instead, they prefer the term *deaf* or (for less severe losses) *hard of hearing* (Lane et al., 1996).

Historically, speech has been erroneously equated with language. Even Furth (1966), who argued that deaf persons can develop logical thinking skills, assumed that they did not have language skills. He, and others, failed to recognize that the vast majority of deaf people readily develop language—namely sign

This article was published Online First July 30, 2012.

Amy R. Lederberg, Educational Psychology and Special Education, Georgia State University; Brenda Schick, Speech, Language, and Hearing Sciences, University of Colorado–Boulder; Patricia E. Spencer, Rockport, Texas.

The authors contributed equally and are listed in alphabetic order. The opinions expressed are those of the authors and do not represent views of the Institute of Education Sciences or the U.S. Department of Education. Portions of this article were supported by Institute of Education Sciences, U.S. Department of Education Grants R324E060035 and R324A110101 to the Georgia State University Research Foundation.

Correspondence concerning this article should be addressed to Amy R. Lederberg, Educational Psychology and Special Education, Georgia State University, P.O. Box 3979, Atlanta, GA 30302-3979. E-mail: alederberg@gsu.edu

language—if they are exposed to it. Numerous researchers have now established that sign languages not only provide a valid way to communicate but are, in fact, true languages with all the properties of spoken languages (e.g., Friedmann & Szterman, 2011; Stokoe, Casterline, & Croneberg, 1965). Research emphasizing similarities between sign and spoken languages has helped counteract the "deficit" view of deaf individuals (Wilbur, 2011).

Until the late 1990s, the vast majority of children with profound hearing loss lacked sufficient access to sound to acquire spoken language (Moores, 2010). Many professionals concluded that most DHH children with this degree of hearing loss would acquire only visually-based language (P. E. Spencer & Lederberg, 1997). However, two major advances have diversified possible linguistic trajectories. First, new technologies allow identification of hearing loss at birth (Harkins & Bakke, 2011), whereas in the 1990s, average age of identification in the United States was around 24 months (Culpepper, 2003). Except for DHH children with deaf parents, late identification meant years of language deprivation. Researchers have documented dramatic improvements in language outcomes (whether signed or spoken) with neonatal identification of hearing loss and intervention implemented by 6 months of age (Yoshinaga-Itano & Sedey, 1998). Almost all industrialized countries have adopted policies for universal neonatal hearing screening (National Center for Hearing Assessment and Management, 2011) and provide early intervention promoting access to visual and/or spoken language. While intervention before 6 months is not always achieved, the average age of intervention has decreased dramatically (Niparko et al., 2010).

Second, technological improvements have increased many DHH children's ability to perceive auditory information and acquire spoken language (Harkins & Bakke, 2011). Hearing aids, using digital processes that accommodate individual hearing profiles, deliver higher quality auditory signals to children with mild to severe losses. Cochlear implants (CIs) allow many (albeit not all) children with profound hearing loss access to spoken language. CIs are surgically-implanted devices that convert auditory information into electronic signals that are delivered directly to the auditory nerve. Time and intervention is required for most users to utilize the information provided. Earlier age of implantation tends to improve outcomes. Even so, auditory input from CIs and hearing aids is not as detailed as that received by hearing children, and these technologies do not result in DHH children becoming "just like" hearing children. In fact, there is a wide range of benefits, and some children do not gain access to speech. In addition, cochlear implants cannot be used with DHH children with certain abnormalities of the cochlea or auditory nerve. They are also less effective for children with multiple disabilities (Pyman, Blamey, Lacy, Clark, & Dowell, 2000; P. E. Spencer, 2004), who are estimated to comprise up to 40% of children in the United States with hearing loss (Mitchell & Karchmer, 2004).

Characteristics of children's language learning environment also affect development. About 5% of DHH children have signing deaf parents (DoDP) and are typically surrounded by deaf adults and children who use sign language (Mitchell & Karchmer, 2004). These children thus learn (sign) language at typical rates and through natural interactive experiences. In contrast, about 95% of DHH children have hearing parents who require various kinds of supports to provide their children with accessible visual or spoken language.

Parents of DHH children and the professionals advising them typically choose among several language-learning approaches that are based on different assumptions about language learning. Philosophical opinions of professionals, the family, and both hearing and DHH acquaintances influence decisions about types of language input to be provided. Underlying these decisions, for many, is belief about the extent to which spoken language is necessary for a child to fit into a mainstream hearing world versus belief that hearing loss is a difference to be embraced, in part by using sign language. This dichotomy, of course, over-simplifies what are complex decisions. Many other child and family factors should be and often are considered. But it is also true that for many professionals, parents, and DHH adults, their philosophical stance rather than characteristics of an individual child drives decisions.

Models of Language Learning Environments

The following three models exemplify common approaches to providing DHH children access to language.

Sign Language

One model focuses on development in the context of a culturally deaf community that uses a sign language that has developed naturally over time (Wilbur, 2011). In this context, DHH children are expected to acquire sign language through participating in early, naturally-occurring social activities. Various sign languages have developed in deaf communities around the world, but all use visible manual actions. Because of varying perceptual and motor requirements, a natural sign language and a spoken language cannot be produced simultaneously.

Sign languages express meaning through manual signs, body movements and postures, and linguistically-specific facial expressions that are as attuned to the characteristics of visual and gestural processing as spoken languages are to the demands of auditory and oral-motor processing (Fischer & van der Hulst, 2011; Wilbur, 2011). American Sign Language (ASL), for example, uses visually-based complex inflectional and derivational systems to encode aspect, spatial relationships, pronominal agreement, adverbial markers, and in some cases form class. ASL's classifiers are polymorphic constructions in which handshape, location, and movement represent properties of nouns, adjectives, and verbs (Schembri, 2003; Schick, 1990a). Multiple morpho-syntactic features may be simultaneously represented on the hands, the face, in space, in different types of movement, rather than in sequential order typical of spoken languages (Klima & Bellugi, 1979; Wilbur, 2011). Prosody is represented through facial expression, speed and movement of signs, and body movements conveying the complex range of functions that pitch, duration, and loudness do in spoken languages (Nicodemus, 2008; Schick, Marschark, & Spencer, 2006).

An important component of the natural sign language model is the presence of numerous deaf adults and children in the children's environment (Lane et al., 1996). For DoDP children, this occurs naturally without intervention, but in the United States, deaf children of hearing parents (DoHP) often only learn sign language through early intervention or when they enroll in special classes/schools (Moores, 2010). In contrast, other countries (e.g., Norway, Netherlands, Sweden) have national policies stating that all deaf children have the right, and therefore early opportunities, to learn sign language as their first language (Arnesen et al., 2008; Moores, 2010).

Bilingualism is almost always a part of this model, although the type of bilingualism varies by communities. In the United States, sign bilingualism includes the assumptions that (1) ASL should be DHH children's first language and the sole language of routine daily communication, (2) print rather than speech should be the primary vehicle for learning spoken language, and (3) English-based sign systems should not be used (Moores, 2010). In other countries (e.g., Sweden, Norway, Australia), sign bilingualism includes more emphasis on speech and simultaneous communication (see below) to promote spoken language as a second language (Arnesen et al., 2008; Preisler, Tvingstedt, & Ahlström, 2002; Svartholm, 2010).

Simultaneous Communication

A second model was developed by educators in the 1960s and 1970s to capitalize on DHH children's relative ease of acquiring sign. Sign *systems* were developed to provide visually accessible models of semantic and syntactic structures of spoken languages (e.g., English, Swedish). These systems combine signs from natural sign languages with newly-created signs to represent grammatical morphemes of spoken language. Signs are produced based on spoken word order. Sign lexicons are related to spoken lexicons (e.g., the same sign for *run* would be used in both *she runs fast* and *my car runs well*).

Because of these modifications, these created sign systems can at least theoretically be produced simultaneously with speech. When this occurs, the result is termed Simultaneous Communication (SimCom). However, speaking and signing simultaneously is highly challenging, because the duration of signs is longer than that of spoken words, and it is difficult to represent prosody in both modalities simultaneously (Wilbur, 2011).

The distinction between sign systems and sign languages is important because they involve differences in the input children receive. For DHH children with functional hearing, language input from SimCom will be bimodal. For those without functional hearing, the input will be predominately visual, but will follow the structure of a spoken language. Finally, the production of sign systems by hearing adults varies considerably, and omissions and mis-signings are not infrequent; thus, R. Johnson, Liddell, and Erting (1989) suggest that SimCom is more accurately described as Sign Supported Speech, with the most complete model usually presented through the auditory mode.

Spoken Language

The third model is one in which the goal is for DHH children to become as much like hearing children as possible in their language and literacy behaviors. In this model, DHH children are exposed to spoken language only, with approaches varying in the degree to which use of gestures and speech reading are encouraged. From the 1900s to 1960s, auditory-oral approaches were dominant in most countries, and the majority of DHH children were given access to sign language only after they failed to acquire spoken language, typically in late childhood or early adolescence (Moores, 2010). Oral-only approaches are again becoming increasingly popular, with hearing aids or CIs being an essential component. Use of this model is based on the assumption, despite lack of supporting evidence and even the presence of opposing evidence, that exposure to sign in any form will interfere with development of spoken language (P. E. Spencer & Marschark, 2010).

Development of Children in the Three Models

In the United States, the proportion of DHH children educated within the three models has changed over recent decades. One national survey found that 52% of children with mild to profound hearing loss were in classes with spoken language alone, 35% with SimCom, and 11% with sign alone (Gallaudet Research Institute, 2008). Comparison with past survey data (Gallaudet Research Institute, 2001) indicates the proportion of children instructed with SimCom decreased by 15%, while spoken-only and sign-only increased 7% and 5%, respectively. This may reflect the increase in the proportion of DHH children with functional hearing as well as evidence that sign language is a better model for language development than sign systems. Researchers in Sweden and the Netherlands (as well as the United States) report a decrease in sign bilingualism and increase in DHH children being mainstreamed with their hearing peers as the use of CIs increases (Hermans, Ormel, & Knoors, 2010; Moores, 2010), and benefits of early intervention allow more age-appropriate language development.

Our review has contextualized DHH children's language development within these models because of the differences in input they provide. However, it is important to stress that the models as described are idealized and oversimplify variations in individuals' experiences. Programs, teachers, parents, and others demonstrate a wide range of fidelity to the target model, and children are exposed to more than one model over time and in different contexts.

In addition, the nature of language development within each context is not solely the result of that context. Models are confounded with (among other factors) parent hearing status and children's functional hearing. Consistent with their own primary languages, deaf parents typically choose natural sign or sign-bilingual approaches, while hearing parents are more likely to choose an oral approach. Parent fluency and the presence of other adults and children who use the system clearly influence rate and patterns of learning. Children's functional hearing also correlates with their language learning context and their ability to learn from it. Analysis for the current article of data from a recent study (Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008) found that 95% of DHH children in oral programs had good speech perception skills, compared with 60% of children in SimCom and 40% in bilingual programs. This undoubtedly reflects matching the characteristics of children to the appropriate program (with those with more functional hearing tending to be in programs emphasizing spoken language) and is therefore a predictor rather than outcome of the primary language-learning context.

DHH children vary on additional factors that mediate language learning success: age of identification; if/when the family begins receiving support from professionals, other families, and other individuals with hearing loss; the ability of family members to learn sign language; and access to professional services and technology. In truth, the list of factors is much longer. Childhood hearing loss occurs within the context of the family, community, culture, and educational system. Not surprisingly, DHH children's language development is also influenced by factors associated with hearing children's language development, including parental involvement, socio-economic status, access to quality early childhood education, and support from the community and extended family.

Complex interactions among these factors challenge descriptions of DHH children's language development trajectories. In addition, the low incidence of hearing loss often limits sample sizes. Small, heterogeneous samples as well as recent changes in age of identification/intervention and use of advanced technologies further restrict generalization of previous findings to current cohorts. P. E. Spencer and Marschark (2010) argue, however, that cautious comparisons of available research findings over time, across cohorts, and varied methods could provide trustworthy overall indicators of the developmental progress of DHH children. With these caveats in mind, the following summarizes research findings about children's development in the three types of environments described above.

Development of Children Learning a Natural Sign Language

The development of DHH children with deaf parents (DoDP) not surprisingly differs in important ways from that of DHH children with hearing parents (DoHP), even when a natural sign language like ASL is expected to be the first language for both groups. Most DoDP children are immersed in a fluent-signing environment and therefore learn sign language easily and naturally; DoHP children, however, usually experience delays in language because of their decreased (and typically later) exposure to persons who provide fluent models (P. E. Spencer & Marschark, 2010).

DHH children with deaf parents who are fluent signers. Most DoDP children experience an environment in which sign language is available from birth and in which being deaf is seen as normative (P. E. Spencer & Harris, 2006). Early communication of signing deaf parents and their infants is similar along many dimensions to that of hearing parents and infants, but deaf mothers use even more touch and visual communication (Meadow-Orlans, Spencer, & Koester, 2004). Deaf mothers adapt to the specific processing demands of visual language and children's developing abilities by producing child-directed forms which tend to be short and repetitive (Holzrichter & Meier, 2000; Meadow-Orlans et al., 2004; P. E. Spencer & Harris, 2006). They also use tactile signals to sensitively direct or redirect attention, position their hands and bodies to produce signs within the infant's field of vision, and/or time sign production to occur while children are looking at them. As children's visual attention matures, mothers decrease use of special visual attention strategies and begin to sign longer utterances in typical signing space (Bailes, Erting, Erting, & Thumann-Prezioso, 2009; Waxman & Spencer, 1997).

With provision of rich sign language models and the adaptations described above, the rate and pattern of DoDP children's early ASL development parallels early spoken language development (Meadow-Orlans et al., 2004; Meier & Newport, 1990). For example, prior to producing signs, deaf infants produce manual babble (Meier & Willerman, 1995; Petitto, Holowka, Sergio, & Ostry, 2001). As actual signs emerge, children make systematic articulatory errors (Conlin, Mirus, Mauk, & Meier, 2000) reflecting (like hearing children's early words) phonological complexity (Szameitat & Schick, 2010). For example, the ASL sign for *mother* is commonly misarticulated by infants and toddlers using a pointing index finger instead of the canonical "number 5" handshape (Meadow-Orlans et al., 2004).

Vocabulary development of DoDP children appears very similar to that of hearing children. Using an ASL-adaptation of the MacArthur Communicative Development Inventory (CDI; Fenson, Dale, Reznick, & Bates, 1994), Anderson and Reilly (2002) collected parent-report data on expressive vocabulary for 69 DoDP children from 8 to 36 months, with longitudinal data collected for 34 children. Average lexical size of DoDP children actually exceeded the average reported for the hearing normative sample before the age of 18 months, with hearing children catching up to the DoDP children by 24 months. Using a British Sign Language (BSL) adaptation of the CDI, Woolfe, Herman, Roy, and Woll (2010) found that a substantial proportion of 29 DoDP children had a sudden increase in vocabulary acquisition when lexical size reached 50 signs (at about 16–19 months of age). In addition, these studies found the content of DoDP children's lexicons similar to that typically reported for hearing children, although the former group had a slightly larger proportion of action, adverbs, and personal-social words.

There are similar parallels in grammatical development. Production of single signs is followed in the early to mid-second year of life by production of signs combined with pointing gestures and soon afterward by expressions containing two actual signs (Morgenstern, Caët, Collombel-Leroy, Limousin, & Blondel, 2010; Schick, 2002). Gestures such as pointing continue to accompany multi-unit expressions just as they do in spoken language. In ASL, however, points eventually also become a part of the linguistic system and take on the role of pronouns by around 17–20 months (Bailes et al., 2009; Petitto, 1987; Pizzuto, 1990). Verb agreement emerges around ages 2–2;6 (years; months) (Morgan, Herman, Barriere, & Woll, 2008; Schick, 2011), but agreement with abstract and absent referents does not appear to fully develop until 5 years of age and may still be problematic in complex narratives (Schick, 2011). Similarly, classifiers emerge as early as 2 years of age but have a prolonged developmental timetable, with mastery around ages 6–8 years of age (Bailes et al., 2009; Schick, 1990b; T. Supalla, 1986).

The unique properties of ASL and other sign languages are learned readily and through typical interactive experiences by DoDP children. Thus, being deaf does not lead inevitably to language deficits.

DoHP children learning a natural sign language. Research on development of natural sign languages by DHH children with hearing parents is surprisingly scant. One body of research focuses on effects of late or restricted exposure to sign language, and provides evidence of a critical period for acquisition of a first language. Deaf communities include individuals who initially experienced oral-only language environments but did not successfully acquire spoken language. They were thus often not exposed to an accessible (sign) language until they were beyond typical language-learning ages. Mayberry and colleagues (see Mayberry, 2010, for a review) conducted a series of studies that showed that such adults, even after 20–40 years of experience using ASL as their primary means of communication, had significant language deficits compared to native DoDP signers (see also Newport, 1990). The extent of linguistic deficits, furthermore, was highly correlated with the age of their initial exposure to ASL, suggesting a critical period for acquiring a natural sign language as a *first* language. In contrast, Mayberry (1993) studied adults who lost hearing in late childhood (having previously acquired spoken English) and acquired ASL as a *second* language during adolescence. These adults became fluent in ASL and did not show the types of partial learning and ASL errors seen in those who had been language-deprived during early childhood. She concluded that there is a critical period *only* for acquiring a first language. Similar to hearing children's acquisition of a second language, it may be that ASL can be fully acquired as a second language after the timely acquisition of any fluent first language, even if it is spoken. At least historically, this is something that DHH children rarely have been able to do.

Conducting and interpreting research on sign language development of DoHP children is challenging because of the small number of these children in fluent signing environments and the lack of standardized assessment instruments (Hermans, Ormel, & Knoors, 2010). This research suggests DoHP children in sign language environments are, on average, very language-delayed compared to DoDP children, with more heterogeneity among the former group (Hermans, Knoors, & Verhoeven, 2010; Maller, Singleton, Supalla, & Wix, 1999; Musselman & Akamatsu, 1999). For example, Prinz and Strong (1998) found that ASL scores of DoHP children in bilingual programs, ages 8–15 years, were significantly below those of DoDP peers. On the other hand, Musselman and Akamatsu (1999) found about 84% of DoHP adolescents in their study were rated intermediate or above in their ability to communicate when conversing in ASL, indicating they were able to converse fluently about everyday topics. More recent research shows improved ASL development in DoHP children (Schick, de Villiers, de Villiers, & Hoffmeister, 2007). The more proficient DoHP children in Schick et al.'s (2007) study may have benefited from early intervention and may have experienced higher quality home and school language learning environments than previous cohorts.

DoHP children's sign language ability relates to parents' signing ability (Meadow-Orlans et al., 2004; Meronen & Ahonen, 2008). Unfortunately, research suggests many hearing parents do not learn to sign fluently. For example, DeLana, Genry, and Andrews (2007) found that half of the hearing parents with children in sign-bilingual programs in the United States did not sign; half reported intermediate to advanced skills. Similarly, while 63% of Norwegian parents stated knowledge of sign language was important for their DHH children, only 27% reported using sign to communicate with them (Arnesen et al., 2008). This same study found that many hearing teachers also reported lack of fluency in sign language, with self-ratings at the midpoint of a rating scale.

While it is true that many hearing parents and professionals do not attain fluency in natural sign language, there is some evidence that children can learn it from less than optimal input. Singleton and Newport (2004) reported on a 7-year-old deaf child who attended a school using Manually-Coded English. The child's only model of ASL use was provided by his deaf parents, who had been educated using only spoken English and did not learn ASL until after 15 years of age. Although the parents used ASL daily, they continued to perform below adult native-signer levels with frequent production inconsistencies and morphological errors. Despite deficiencies in his ASL input, the child developed ASL that was more regular than his parents' and was, in many aspects, comparable to that of a similarly-aged group of native-signing children whose parents signed ASL fluently. This suggests that a less than perfect model of natural sign language, when used frequently and in naturally-occurring interactions, can stimulate language-learning mechanisms that support effective systematization and building of rule-governed language. Similarly, researchers have documented emergence of a sign language in Nicaragua, where early generations of DHH children have received input best characterized as a pidgin language. The sign language developed was more systematic and more linguistically complex than their input and closely resembles other sign languages (Senghas & Coppola, 2001).

In summary, DoHP individuals whose first language is sign and who do not have early exposure to sign show a clear difference from typical developmental trajectories. However, some research suggests DoHP children develop grammatically-correct sign language with early access to sign models, even when the sign model is imperfect. More research is needed to better understand the conditions necessary to support fluent and complete development.

DHH children and sign bilingualism. Sign language development almost always occurs under bilingual conditions, in that all DHH children are learning a spoken language (either through print or through speech) in addition to sign language. However, with the exception of research on literacy skills (described below), only a few researchers have examined DHH children's bilingual development. These studies suggest that DHH children can attain bilingual competencies. Musselman and Akamatsu (1999) rated 51 DHH adolescents' proficiency when participating in spoken only, SimCom English, and ASL conversations. There was a significant correlation ($r = .51$) between SimCom English and ASL skills. Forty-nine percent were equally proficient in ASL and SimCom English. An additional 26% scored highest in ASL, 16% in SimCom, and 10% in spoken English. DoDP children scored higher than DoHP in both ASL and SimCom competence. Hoffmeister (2000) also found a moderate correlation between ASL and SimCom English.

When DHH children have functional hearing, there is emerging evidence that they can acquire both signed and spoken languages when input includes both. Hermans, Ormel, and Knoors (2010) studied vocabulary and morphosyntactic skills in Sign Language of the Netherlands (SLN) and spoken Dutch in 75 children (46 with cochlear implants) from bilingual programs. Children were split into two age groups: younger (mean age = 4.8 years) and older (mean age = 7.0 years). Average scores on all tests increased with age, suggesting children within these programs were developing both signed and spoken language. Older DHH children's scores on vocabulary and morphosyntax in SLN were moderately correlated with scores in spoken Dutch but this was not the case for the younger children. Hermans, Ormel, and Knoors (2010) suggest that increased time in the bilingual education environment promoted the acquisition of both languages, especially when children had some functional auditory access.

Development of Children in Simultaneous Communication Environments

A primary goal of SimCom input, in which sign and speech are produced near-simultaneously, is to enable children to acquire the semantics and syntax of spoken language and to provide them with visual support for learning. For children with limited functional hearing, the primary input they receive is the visual signing system (e.g., signed English). Two challenges confront these children. First, some researchers have argued that the grammatical structure of spoken languages cannot successfully be acquired through signed systems (e.g., Gee & Mounty, 1991; Wilbur, 2011) because they are not naturally adapted to the visual-gestural modality. Second, children acquiring signed systems usually have hearing parents and have received less than optimal signing input from parents (Lederberg & Everhart, 1998; P. E. Spencer & Harris, 2006). Recent national survey results indicate that this remains the case in the United States, with only half of DHH children in signing school environments having family members who sign regularly with them (Gallaudet Research Institute, 2008). Given relations between frequency of parent sign and children's language development (Lederberg & Everhart, 1998; Meadow-Orlans et al., 2004; Musselman & Akamatsu, 1999) and teachers' variability in fluency and adherence to SimCom (Akamatsu & Stewart, 1998; Power, Hyde, & Leigh, 2008), the potential effects of SimCom (and of signing systems) may not have been effectively tested.

Vocabulary. Summarizing studies that preceded the advent of universal newborn screening and early intervention, Lederberg and Beal-Alvarez (2011) concluded that vocabulary development of DHH children in SimCom environments was severely delayed, with greater variability than in DoDP and hearing children. By the end of preschool, average lexicons were more than two standard deviations below those of hearing peers and differences increased with age. Lederberg and Spencer (2009) found in studies of fast-mapping that lexical size is strongly related to children's cognitive strategies for vocabulary learning. Thus, language delays may lead to differences in language learning.

Newborn screening and early intervention can result in improved vocabulary development. With identification of hearing loss by 6 months of age, Mayne, Yoshinaga-Itano, Sedey, and Carey (1999) found that DHH children's average vocabulary development was between 5th and 25th percentiles on tests normed for hearing children. Moeller (2000) found vocabulary levels within the average range for some of a group of 112 5-year-old DoHP children with hearing aids. These children, who had hearing losses ranging from mild to profound, had been placed in either SimCom or oral-only language environments based on what was "most appropriate to meet the needs of the child and family" (Moeller, 2000, p. 3). Level of family involvement and age of identification of hearing loss had impact on vocabulary development but type of language environment did not. It is likely that quality of programming also affected the positive outcomes identified in both of these research efforts.

Unlike past cohorts, DHH children with functional hearing promoted through early use of CIs or advanced hearing aid technology can actually receive bimodal input in SimCom environments. Emerging research suggests that, despite theoretical arguments to the contrary (R. Johnson et al., 1989), DHH children can integrate bimodal input. Nittrouer (2010) examined the language development of 118 DHH children who were identified early and had moderate to profound hearing losses. A subgroup of 80 had CIs. At 24 months and 30 months, DHH children whose mothers used SimCom (about a third of the total sample) had larger vocabularies than those whose mothers used only spoken language. These children's 24-month expressive vocabulary included both signed (44%) and spoken words (56%). Mothers and children decreased use of sign as the children's spoken language developed, and after 30 months of age, effects of communication mode disappeared.

Syntax. DHH children show more delays and differences in syntax than in other areas of language. Severe delays and differences have been reported for children who have little functional hearing and therefore must rely solely on signed input. Problems with morphosyntax (Schick & Moeller, 1992) and word order are reported into adolescence (Singleton, Supalla, Litchfiled, & Schley, 1998). S. J. Supalla (1991) found that DHH 9- to11-year-olds in a SimCom environment varied in their ability to use standard English Subject–Verb–Object word order (42%–100% correct), using non-English word orders in up to 32% of sentences. Better knowledge of syntax has been observed in classrooms in which teachers used SimCom more consistently, but grammatical morpheme use continues to present special difficulties, even when children have some access to spoken English (Power et al., 2008; Schick & Moeller, 1992). English syntactic development, although delayed, does seem to improve with age and SimCom experience. For example, Akamatsu, Stewart, and Becker (2000) found evidence of continuing improvement in morphosyntax (e.g., articles, plurals) during late elementary and even middle school years.

DHH children with CIs show integration across modalities which results in improved syntactic development. L. J. Spencer, Tye-Murray, and Tomblin (1998) reported that students using CIs in SimCom language environments acquired English grammatical morphemes. The students produced those morphemes primarily through speech but continued to sign (and also often speak) content words. As an example, a child may have signed "My Dad work on farm" but said "My Dad works on a farm." This pattern demonstrates that, with access to sufficient auditory information, students were able to synthesize visual and auditory input and produce morphemes in the sensory modality to which they are best suited.

Spoken Language Development of DHH Children

Historically, only a small proportion of children with severe to profound hearing loss were successful in acquiring spoken language (Blamey et al., 2001). Early intervention—which includes use of amplification (hearing aids) in the first year of life and, often, cochlear implantation before 2 years of age—has resulted in better functional hearing and improved spoken language outcomes for many DHH children. However, not all children with profound loss are candidates for use of cochlear implants (Nicholas & Geers, 2006), and some children with cochlear implants do not appear to gain significant functional hearing. For these children, spoken language is rarely a viable goal.

Given the rapid changes over the last 20 years, our understanding of spoken language development of DHH children is just emerging, and the degree to which research on children who were implanted even 10 years ago will generalize to the current cohort of children is unknown. Because of funding priorities aimed at understanding the effect of innovative technology on spoken language development, most recent studies have focused exclusively on children with CIs. Researchers have just begun to include children with lesser losses in their studies of spoken language. Caution should be used in generalizing these results to the DHH population as a whole. Almost universally the studies have inclusion criteria that result in a sample of children without multiple disabilities, and parents who speak only the school language (e.g., English in the United States or United Kingdom) in the home and who have adopted a goal of spoken language for their DHH child.

The most effective language learning context for developing spoken language skills continues to be debated (P. E. Spencer & Marschark, 2010). While some professionals argue that spoken language is best developed in exclusively oral environments, extensive research has failed to support this conclusion. Findings include (a) small but significant advantages for children in oral compared to SimCom programs (Geers, Moog, Biedenstein, Brenner, & Hayes, 2009; Geers, Nicholas, & Sedey, 2003), (b) no effect of communication modality (Niparko et al., 2010; Nittrouer, 2010), and (c) an advantage for SimCom for vocabulary growth (Connor, Heiber, Arts, & Zwolan, 2000). Language input is typically confounded by initial characteristics of children and by families changing their DHH children's language input based on individual rates of spoken language development (Watson, Archbold, & Nikolopoulos, 2006). For those in SimCom environments, researchers have reported that both hearing parents and their DHH children typically decrease their use of sign when (and if) spoken language skills develop (Geers, Spehar, & Sedey, 2002; Nittrouer, 2010). P. E. Spencer and Marschark (2010) conclude that SimCom, at the very least, does not interfere with acquisition of speech.

National surveys in the United States track only what communication mode is used in educational contexts and not what language DHH children use to communicate. Therefore, we cannot know from these surveys what proportion of DHH children is actually acquiring fluent spoken language. One study of almost all DHH children in a large U.S. metropolitan area who were being educated in special classes for children with hearing loss found about 70% of children were able to identify the referent of spoken words (voice only) on a speech perception test, and thus appeared, at least to some extent, to be acquiring spoken language (Easterbrooks et al., 2008). In an Australian study, Hyde and Punch (2011) found 70% of children with CIs used speech alone as their preferred mode of communication and 30% used sign and speech.

There are a number of factors that have been found to have significant effects on spoken language development of children who use CIs or have more moderate hearing losses. These factors account for 35%–50% of the variance in spoken language outcomes (Geers et al., 2009; Geers & Sedey, 2011; Niparko et al., 2010; Nittrouer, 2010). As has been true with language development in hearing children, the most significant factors predicting spoken language include parental education, socio-economic status, ratings of parental sensitivity and stimulation, and parent involvement (Geers et al., 2009; Niparko et al., 2010). Children's nonverbal cognitive skills also relate to language development in general and spoken language development specifically (Geers et al., 2009). Factors related to access to audition also relate to spoken language development. More positive outcomes occur with earlier amplification, longer use of cochlear implants, greater residual hearing (or shorter periods with hearing loss) prior to use of the cochlear implants, and severity of hearing loss for children using hearing aids (Fitzpatrick, Crawford, Ni, & Durieux-Smith, 2011; Geers, 2006; Niparko et al., 2010). Because only children with the most severe or profound hearing loss receive cochlear implants, severity of loss no longer relates linearly to spoken language outcomes for the DHH group as a whole. Leigh, Dettman, Dowell, and Sarant (2011) found that implanted children with severe to profound loss performed similarly on speech and language tests to those with moderate losses who used hearing aids and better than children with severe to profound losses with hearing aids.

Most researchers conclude that cochlear implantation by 2 years may be critical to optimal language outcomes, though later implantation still results in improved spoken language compared to profoundly deaf children using only hearing aids (Dettman & Dowell, 2010; P. E. Spencer, Marschark, & Spencer, 2011). Researchers have proposed two reasons for this effect. First, for many with profound loss, access to spoken language typically begins when implantation occurs. Therefore, the later the implantation the more delay has been experienced. Second, lengthy auditory deprivation can change auditory perception permanently, and thus can compromise ongoing access to speech. Sharma, Nash, and Dorman (2009) found evidence that auditory deprivation leads to permanent change in auditory pathways, and that only cochlear implantation before 3.5 years results in DHH children having cortical responses to auditory stimuli similar to those of hearing children.

Speech development. While not synonymous with language, speech intelligibility is crucial to communication when DHH use spoken language. Children with early identification of hearing loss, lesser degrees of hearing loss, and those with earlier CI implantation appear to have the best outcomes. Researchers have found the early phases of prelinguistic development in early-identified children, whether using CIs or hearing aids, to be delayed but to follow similar steps as in hearing children. However, there were subtle differences in production of more complex babbles, and DHH children's speech productions were generally more variable than those of hearing children (Ertmer & Goffman, 2011; Moeller, Hoover, et al., 2007; Schauwers, Gillis, & Govaerts, 2008). Finding that complexity of prelinguistic babbles correlated with later articulation scores, Moeller, Hoover, et al. (2007) concluded that the motor and phonetic foundations for spoken language are acquired through babbling. Thus, prelinguistic vocalizations appear to be an important indicator of infants' ability to learn spoken language. Unfortunately, researchers indicate that articulation problems may continue to interfere with communication experiences of many DHH preschoolers (Nittrouer, 2010; Tobey, Geers, Brenner, Altuna, & Gabbert, 2003). Fitzpatrick et al. (2011) found speech production the most impaired of all speech and language measures for a group of 4- and 5-year-olds, including those with CIs and those with less severe loss using hearing aids. Nittrouer (2010) concluded, "In general, (preschool) children with hearing loss were quite unintelligible, with listeners able to understand less than half of the words these children said" (p. 181).

Spoken language development. Many researchers report that DHH children's lexicons are smaller than those of hearing toddlers (Moeller, Hoover, et al., 2007; Nott, Cowan, Brown, &

Wigglesworth, 2009), even with early intervention and use of advanced technologies, although the overall difference is much less than that of earlier cohorts (Mayne et al., 1999). On the other hand, some researchers have found average vocabulary *growth* curves of children with early cochlear implantation equal or even exceed those of hearing children (Connor & Zwolan, 2004; Dettman & Dowell, 2010; Nittrouer, 2010; Tomblin, Barker, Spencer, Zhang, & Gantz, 2005). For children who received high quality early intervention and preschool education, growth appears to be sufficient to result in about half the children entering school with close to age-appropriate vocabulary skills (Fitzpatrick et al., 2011; Geers et al., 2009; Hayes, Geers, Treiman, & Moog, 2009; Nittrouer, 2010). In these studies, average vocabulary scores were in the "low normal" range (i.e., standard score of around 85) by 4–5 years of age.

DHH children's syntactic development shows a different pattern from that of hearing children, and this pattern is consistent across various spoken languages (P. E. Spencer & Marschark, 2010). Researchers have found slower growth in Mean Length of Utterance (MLU) for children with CIs acquiring English, German, or Dutch and greater diversity in outcomes compared to hearing children (Schauwers, Gillis, & Govaerts, 2005). In addition, hearing loss tends to affect syntax more than vocabulary (Edwards, Figueras, Mellanby, & Langdon, 2011; Geers et al., 2009; Inscoe, Odell, Archbold, & Nikolopoulos, 2009).

Perceptual salience plays a role in DHH children's acquisition of spoken grammatical morphemes (Koehlinger, Horne, & Moeller, 2011; Szagun, 2004). For example, Koehlinger et al. (2011) found that English-speaking children with hearing loss were more delayed in their acquisition of the difficult to hear *–s* morphemes (contracted is, plural *–s*, possessive *–s*) than syllabic morphemes (uncontracted *am*, *is*, *are*, progressive *–ing*, *a*, and *the*). Similarly, Szagun (2004) found children with CIs showed more errors with the harder-to-hear aspects of the German article system compared to hearing children who were matched on MLU.

Summary of Spoken Language Development

In summary, a larger proportion of DHH children today than in the past is acquiring spoken language within age ranges typical for hearing children. This is due to a combination of factors including earlier identification and intervention for hearing loss, use of advanced technologies, and enhanced educational efforts. For hearing families, this means these children are able to participate more fully in conversations in their families' native spoken language. However, there are still large numbers of DHH children who are significantly delayed in spoken language skills despite use of advanced technology like CIs. Like so many DHH children in the past, children who are experiencing delayed spoken language development but are not given access to alternative models may be unable to develop language skills sufficient to support fluent communication or serve as a basis for further learning.

Impact of Hearing Loss on Language-Related Cognitive and Academic Skills

Questions have been raised about effects of the language development delays and differences of DHH children on their language-related cognitive and academic abilities. In this section, we examine the possible cascading effects of delayed language on two of these abilities, specifically children's developing Theory of Mind (ToM) and print literacy skills.

Development of Theory of Mind

Hearing children's language skills are strongly predictive of ToM skills (specifically, false belief understanding), and the quality of language input facilitates and may be necessary to acquire ToM skills (Milligan, Astington, & Dack, 2007). It is not surprising, therefore, that DHH children's general language levels also associate with their performance on ToM tasks.

Importantly, there is a robust set of findings that DoDP children who are native signers and whose language development is generally age-appropriate demonstrate ToM skills comparable to those of their age-matched hearing peers (Courtin, 2000, in France; Peterson, Wellman, & Liu, 2005, in Australia; Schick et al., 2007, in the United States; Woolfe, Want, & Siegal, 2002, in the United Kingdom). Having a visual (instead of auditory-based) language does not affect acquisition of fundamental social cognitive skills. This is consistent with research that shows that hearing children's ToM development is not affected by the specific (spoken) language being learned (Wellman, Cross, & Watson, 2001).

In contrast, at least in the past, DoHP children typically showed a severe delay in ToM, with the minimum average delay reported to be about 4 years (Courtin, 2000; Peterson et al., 2005; Schick et al., 2007; Woolfe et al., 2002). Like hearing children, DoHP children's language skills, regardless of modality or specific language (e.g., spoken or signed English, or ASL), predict ToM performance (Moeller & Schick, 2006; Remmel & Peters, 2009; Schick et al., 2007).

DoHP children's average delay in ToM may also be related to characteristics of language input from their parents. Moeller and Schick (2006) compared SimCom input from hearing mothers to their DHH children (none with CIs) with that of hearing mothers and their hearing children. Results showed that mothers of hearing children used a greater diversity of mental state terms than mothers of the DHH children. For both groups, the general quality of language input and mothers' use of mental state terms predicted their children's ToM performance. This relation held for the DHH children even after accounting for child age and level of language skill. Mothers who used few mental state signs had DHH children with low ToM skills. The importance of the quality of language input in the educational environment was suggested by results of a study of two groups of DoDP children (in Italy, Sweden, and Estonia). Those who were in sign-bilingual/bimodal programs had ToM skills similar to (slightly younger) hearing peers; however, DoDP children in oral programs showed delays in ToM (Meristo et al., 2007). Thus, access to language input in a variety of situations, as well as language levels attained, appear to influence the development of DHH children in ways similar to those documented for hearing children. As a result, many DoHP children enter school unable to pass ToM tasks that are typically achieved at age four by hearing children, and this delay in understanding cognitively-related situations may have far-reaching effects on the children's ability to learn in traditionally age-based educational activities (Astington & Pelletier, 2005).

A more recent study found that DHH children with CIs who had close to age-appropriate language levels performed similarly on

ToM tasks to (slightly younger) hearing children (Remmel & Peters, 2009). Evidence that these DHH children, like DoDP children, had typical rates of ToM development supports the premise that higher levels of language development (whether in sign or speech) leads to better social-cognitive skills.

Development of Literacy

Print literacy, specifically the ability to read and write, is critical for full participation in education and employment situations. Unfortunately, literacy has long been an area of difficulty for many DHH children, and their average literacy outcomes have remained significantly below those of hearing children for many decades despite increased emphasis on their achievement and multiple changes in educational interventions (P. E. Spencer & Marschark, 2010). Throughout the 20th century, national surveys in the United States consistently found that the average DHH high school student graduated reading at the fourth grade level, with only 10% developing age-appropriate skills (Traxler, 2000). Similar results have been found across languages differing in orthography and language learning contexts, including Spanish (Alvarado, Puente, & Herrera, 2008), Dutch (Hermans, Ormel, & Knoors, 2010), and Chinese (Yang, 2008). Improved but still problematic results are emerging about the current cohort of DHH children who benefit from early intervention and use of advanced technologies (Geers & Hayes, 2011; L. J. Spencer & Tomblin, 2009).

Although many skills and experiences contribute to acquisition of literacy, two have received the most attention: general underlying language abilities, and the ability to use spoken phonological knowledge for decoding printed words. There is growing recognition that these two abilities differ within the population of DHH children depending on their degree of functional hearing and access to the sound-based phonological system which is a foundation of written language (Easterbrooks et al., 2008; Hermans, Ormel, & Knoors, 2010).

Literacy skills of DHH children with limited functional hearing. DHH children who sign (either signed systems or sign language) *and* have poor access to speech are learning to read a language that differs in many ways from their own. Indeed, they must learn to identify words through means different from those of hearing children or of DHH children who acquire spoken language. Hearing children learn to identify written words in part by decoding or matching graphemes to an already stored spoken phonological representation (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). In contrast, DHH children with limited functional hearing frequently have either weak or non-existent spoken phonological representations of words and print does not correspond to the phonemes of their signs (e.g., handshape configuration; Bochner & Bochner, 2009; Musselman, 2000).

Some theorists argue that reading by DHH and hearing children is qualitatively similar and that visual and kinesthetic means must be used to develop spoken phonological representations of printed words (Wang, Trezek, Luckner, & Paul, 2008). Such knowledge can be at least partially derived from lip-reading and speech articulation (Harris & Moreno, 2006), and use of special techniques developed for DHH children such as Visual Phonics and Cued Speech (for reviews, see LaSasso, Crain, & Leybaert, 2010; Musselman, 2000; Perfetti & Sandak, 2000). These reviews indicate that although some DHH children with limited functional hearing develop some spoken phonological representation, these alternative means do not result in many DHH children developing age-appropriate phonological awareness or reading skills.

Other theorists (Allen et al., 2009; Goldin-Meadow & Mayberry, 2001) argue that reading does not require translation into spoken phonemes, and alternative visually-based strategies can be employed to identify words. The most frequently suggested strategy is the use of children's sign language skills. For example, one strategy that DHH readers use is to map a holistic printed word to its meaning either directly or mediated by a related sign (Siedlecki, Votaw, Bonvillian, & Jordan, 1990). While this may result in good reading skills for some DHH readers (Koo, Crain, LaSasso, & Eden, 2008; Morford, Wilkinson, Villwock, Pinar, & Kroll, 2011), the low literacy attainment suggests it is not an effective strategy for most DHH readers. Indeed, research with hearing children suggests this sight word strategy would be ineffective for a majority of children (Rayner et al., 2001). Experimental research also indicates that learning new written words through associations with sign can be a slow process for DHH children (Reitsma, 2009).

Two visually-based strategies may help DHH children to develop a representational structure that can mediate word reading. Fingerspelling, which consists of a manual alphabet representing orthography, is a natural part of sign languages, and when produced fluently may provide a non-auditory phonological system that can be used to represent the internal structure of written words and aid decoding and memory (Alvarado et al., 2008; Haptonstall-Nykaza & Schick, 2007; Hirsh-Pasek, 1987; Padden & Ramsey, 2000). Fluent fingerspelling represents some syllable structure and co-articulated chunking of frequently co-occurring letter sequences (Brentari, 1998; Wilcox, 1992). For example, consonantal clusters (*bl*, *sl*, *cl*, *str*) or common affixes (*–tion*, *–ness*, *pre–*) are produced as smooth, co-articulated sequences, not distinct separate letters. Strong correlations have been found between DHH children's fingerspelling skills and English reading vocabulary (Alvarado et al., 2008; Haptonstall-Nykaza & Schick, 2007; Padden & Ramsey, 2000). Training studies have shown that use of co-articulated fingerspelling facilitated learning new print words, with effects particularly strong for DoHP children (Haptonstall-Nykaza & Schick, 2007; Hirsh-Pasek, 1987). Fingerspelling in which each letter is presented individually (and is less sign-like) did not provide such facilitation (Haptonstall-Nykaza & Schick, 2007). Some educators in sign-bilingual programs advocate incorporating fingerspelling in order to build multi-modal word representations: presenting new words in chains of print, sign, and fingerspelling (Padden & Ramsey, 2000). Incorporation of fluent fingerspelling in instruction is a promising technique that may lead to improved reading abilities, but its efficacy has not been rigorously tested.

Other researchers suggest that explicit instruction on morphology can provide DHH children an additional sublexical basis for word identification and generation. Research suggests that most DHH children have poor knowledge of the morphemic structure of the written language (Gaustad & Kelly, 2004) and that such knowledge makes a significant contribution to word identification beyond the third grade for hearing children (Nunes, Burman, Evans, & Bell, 2010). Training studies show that signing DHH children can improve their knowledge of the spoken/written language's derivational and inflectional morphology (Nunes et al., 2010). Future research needs to explore whether programs that systematically develop this type of knowledge result in improved word identification skills across groups of children.

As for hearing children, there is an extensive database indicating that DHH children's literacy outcomes are related to their underlying language skills. This association is found even when that language is a sign language or a signed system. In a meta-analysis of reading studies of DHH children, Mayberry, del Giudice, and Lieberman (2011) found that DHH children's language abilities (signed or spoken) predicted 35% of the variance in their reading ability. Other researchers have found that expressive vocabulary significantly predicted DHH children's reading achievement (Easterbrooks et al., 2008; Hermans, Knoors, Ormel, & Verhoeven, 2008; Kyle & Harris, 2006), but an important role is also played by knowledge of English syntax (Kelly, 1996; Moores & Sweet, 1990a, 1990b).

Sign-bilingual education programs in the United States are based on the premise that a focus on improving sign language skills, thus promoting general language knowledge, will also lead to better reading skills of the spoken language, with the latter acquired as a second language via print. In fact, it is assumed that a fluent natural sign language can serve as the primary language of instruction and be used to support learning (via comparison and contrast) of the second language. As reviewed above, current evidence suggests that DoHP children can acquire sign language in immersion programs, though their language is typically delayed compared to that of DoDP children. However, the degree to which these skills relate to reading is controversial. There are a number of reports that stronger sign language skills correlate with stronger reading skills (Chamberlain & Mayberry, 2008; Hermans et al., 2008; Padden & Ramsey, 2000; Strong & Prinz, 1997). However, other researchers have failed to find such a relation (Mayer & Akamatsu, 2011; Moores & Sweet, 1990a, 1990b). In contrast to consistent differences in sign language skills, researchers have not found consistent differences in reading skills between DoHP and DoDP students (Convertino, Marschark, Sapere, Sarchet, & Zupan, 2009; DeLana et al., 2007). Finally, as Hermans, Ormel, and Knoors (2010) note, these studies have rarely examined DHH children's skills in the spoken or signed version of the written language that is frequently correlated with sign language abilities and may mediate the relations between sign language and reading.

Theorists have suggested the original premise of the sign-bilingual model—that sign language skills will *directly* transfer to understanding the written form of a different language—should be modified (Hermans, Ormel, & Knoors, 2010; Mayer & Leigh, 2010). Good language skills in a first language are a necessary but *not sufficient* condition to learn to read a second language. These researchers posit that transfer between sign and the written form of a spoken language will occur only for the cognitive underpinnings (e.g., conceptual knowledge, uses of language) and those linguistic features the languages share. Hermans, Ormel, and Knoors (2010) suggest that good sign language skills can serve as a mediator for learning to read a second language, but only when teachers explicitly cultivate that transfer. Such cultivated transfer might include emphasis of improving the second language through the signed and spoken medium (i.e., SimCom) while teaching literacy.

Two recent studies suggest explicit literacy instruction can result in improved English syntax (written, signed, and spoken) for DHH children. Nunes et al. (2010) trained elementary school teachers to implement activities that focused on English grammar. With a randomized-field trial design, they found children in the intervention classes performed better on suffix spelling, reading comprehension, and writing tests than those in a control class. Cannon, Easterbrooks, Gagne, and Beal-Alvarez (2011) also found that exposure to a computer-based language program, which focused on comprehension of written sentences, improved elementary-school signing children's written and expressive (in SimCom) knowledge of English morphosyntax.

Literacy skills of DHH children with functional hearing. Like hearing children, DHH children who have sufficient functional hearing to acquire spoken language are learning a written form of the language they already know (Hermans, Ormel, & Knoors, 2010; Mayer & Akamatsu, 2011). Although as reviewed above, spoken language levels remain generally below those of same-age hearing children, research suggests that access to the written language's auditory phonological system provides significant advantages (Easterbrooks et al., 2008; Geers & Hayes, 2011). With auditory access through CIs, advanced hearing amplification, or having a mild-to-moderate hearing loss, average reading skills are somewhat delayed but much closer to levels of hearing peers than has been found in the past for DHH children. Age-appropriate reading skills are attained by many DHH elementary school children (Archbold et al., 2008; Briscoe, Bishop, & Norbury, 2001; Easterbrooks et al., 2008; Gibbs, 2004) and high school adolescents (Geers & Hayes, 2011). However, Harris and Terlekski (2011) found that DHH 12- to 16-year-old children with CIs or hearing aids *on average* had 3 years delay in reading; only 20% were mainstreamed with hearing children and relied solely on spoken language. Rather than being in conflict, these studies may represent different parts of the distribution of DHH children. More research is needed before we know whether recent trends in early identification, digital hearing aids, and cochlear implants will result in improved literacy rates for the majority of DHH children.

Researchers have consistently found that phonological awareness and language correlate both concurrently and predictively with reading for DHH children with functional hearing, suggesting similar processes as hearing children. However, a more nuanced approach suggests there may be differences in how the two groups of children learn to read. While phonological awareness skills correlate with reading skills, DHH children (with CI or with moderate losses) show a more severe deficit in auditory-only phonological awareness compared to their reading scores on tests normed for hearing children (Ambrose, Fey, & Eisenberg, 2012; Colin, Magnan, Ecalle, & Leybaert, 2007; Easterbrooks et al., 2008; James, Rajput, Brinton, & Goswami, 2008; Moeller, Tomblin, et al., 2007; L. J. Spencer & Tomblin, 2009; Webb & Lederberg, 2012). DHH children may rely on visual and kinesthetic cues to phonology available in speech reading, articulation, and print itself to supplement partially-accessible (auditory) phonology as they learn to read (Beal-Alvarez, Lederberg, & Easterbrooks, 2012; C. Johnson & Goswami, 2010; Kyle & Harris, 2006).

There is increasing recognition that phonological knowledge and reading have a reciprocal relationship in both hearing and DHH children. Phonics instruction (i.e., explicit instruction on how graphemes map onto phonemes) allows children to develop more precise phonological representations of words (Castles & Coltheart, 2004). Because graphemes provide visual support for only partially-available phonemes, phonics instruction may be particularly well-suited to support phonological knowledge for DHH children with functional hearing (Beal-Alvarez et al., 2012; Bergeron, Lederberg, Easterbrooks, Miller, & Connor, 2009). Researchers have also found knowledge of grapheme-phoneme correspondences and ability to blend and sound out pseudowords to be better developed and more strongly related to reading than traditional measures of auditory-only phonological awareness for DHH children with functional hearing (Easterbrooks et al., 2008; Geers, 2003; L. J. Spencer & Tomblin, 2009). For children with functional hearing, training studies suggest print can be used to strengthen spoken phonological and morphological skills (Bow, Blamey, Paatsch, & Sarant, 2004; Most, Levin, & Sarsour, 2008).

Vocabulary and syntactic abilities are even more strongly predictive of reading than phonological processing skills. In a longitudinal study of children with CIs (Geers, 2003; Geers & Hayes, 2011), these abilities accounted for more variance (47%) than phonological processing (26%) in elementary school reading scores. In high school, these abilities became even more important, accounting for 56% of the variance, while phonological processing accounted for only 3.8% of the variance in reading abilities (A. E. Geers, personal communication, March 9, 2011). Similarly, C. Johnson and Goswami (2010) found that vocabulary measures explained 24%–49% of unique variance for reading outcomes (depending on measure). Connor and Zwolan (2004) found that pre-implant vocabulary (which was primarily in sign) predicted later reading vocabulary, suggesting that, at least initially, the effect is not modality specific. These findings confirm that for DHH children, regardless of the language model they experience, reading depends on the development of good underlying language skills. We would expect, as for hearing children, language skills are necessary but not sufficient for the development of reading. That is, explicit instruction in literacy may be required to support age-appropriate reading skills, but how instruction should resemble or differ from that of hearing children (Rayner et al., 2001) still needs to be explored.

Conclusion

The rates and patterns of development of language and related abilities in DHH children are as varied as the characteristics of the children themselves, their cultural and family contexts, and their language-learning environments. Diversity is ever present—in degree and configuration of hearing loss, in individual responses to use of amplification or CIs, in family involvement and accommodation to children's needs, in the models to which they are exposed, and in the cognitive and social strengths of individual children.

Thus, the question of whether the development of DHH children in the areas addressed in this article is better characterized as different or deficient cannot be answered for the group as a whole. Developmental trajectories for all DHH children are different from that of hearing children along some dimensions. In addition, there is little to no delay evident for children with accommodating environments that provide readily-accessible language experiences. These children are a minority in the population, however, and delays and profiles of development differ across individuals and the various opportunities they are provided. At this time, it is not possible to accurately predict outcomes for individual children. All approaches to language development require constant and frequent monitoring, rather than a static approach regarding language access or an a priori decision that does not consider the myriad factors related to an individual child and family. Furthermore, there is no evidence that children cannot learn language via multiple modalities or that using a visual language will hinder the development of a spoken language, but there is strong evidence that not having access to language has long term negative developmental effects. While the ongoing challenges are clear, there is also great hope for continued rapid progress in the development of DHH children when their individual needs and abilities to access fluent language input during naturally-occurring interactions early in life are met.

References

Akamatsu, C. T., & Stewart, D. A. (1998). Constructing simultaneous communication: The contributions of natural sign language. *Journal of Deaf Studies and Deaf Education, 3,* 302–319. doi:10.1093/oxfordjournals.deafed.a014358

Akamatsu, C. T., Stewart, D. A., & Becker, B. J. (2000). Documenting English syntactic development in face-to-face signed communication. *American Annals of the Deaf, 145,* 452–463.

Allen, T. E., Clark, M. D., del Giudice, A., Koo, D., Lieberman, A., Mayberry, R., & Miller, P. (2009). Phonology and reading: A response to Wang, Trezek, Luckner, and Paul. *American Annals of the Deaf, 154,* 338–345. doi:10.1353/aad.0.0109

Alvarado, J. M., Puente, A., & Herrera, V. (2008). Visual and phonological coding in working memory and orthographic skills of deaf children using Chilean sign language. *American Annals of the Deaf, 152,* 467–479. doi:10.1353/aad.2008.0009

Ambrose, S. E., Fey, M. E., & Eisenberg, L. S. (2012). Phonological awareness and print knowledge of preschool children with cochlear implants. *Journal of Speech, Language, and Hearing Research, 55,* 811–823. doi:10.1044/1092-4388(2011/11-0086)

Anderson, D., & Reilly, J. (2002). The MacArthur Communicative Development Inventory: Normative data for American Sign Language. *Journal of Deaf Studies and Deaf Education, 7,* 83–106. doi:10.1093/deafed/7.2.83

Archbold, S., Harris, M., O'Donoghue, G., Nikolopoulos, T., White, A., & Richmond, H. L. (2008). Reading abilities after cochlear implantation: The effect of age at implantation on outcomes at 5 and 7 years after implantation. *International Journal of Pediatric Otorhinolaryngology, 72,* 1471–1478. doi:10.1016/j.ijporl.2008.06.016

Arnesen, K., Enerstvedt, R. T., Engen, E. A., Engen, T., Hoie, G., & Vonen, A. M. (2008). The linguistic milieu of Norwegian children with hearing loss. *American Annals of the Deaf, 153,* 65–77. doi:10.1353/aad.0.0000

Astington, J. W., & Pelletier, J. (2005). Theory of mind, language, and learning in the early years: Developmental origins of school readiness. In B. D. Homer & C. Tamis-Lemonda (Eds.), *The development of social cognition and communication* (pp. 205–230). Mahwah, NJ: Erlbaum.

Bailes, C. N., Erting, C. J., Erting, L. C., & Thumann-Prezioso, C. (2009). Language and literacy acquisition through parental mediation in American Sign Language. *Sign Language Studies, 9,* 417–456. doi:10.1353/sls.0.0022

Beal-Alvarez, J. S., Lederberg, A. R., & Easterbrooks, S. R. (2012). Grapheme-phoneme acquisition of deaf preschoolers. *Journal of Deaf Studies and Deaf Education, 17,* 39–60.

Bergeron, J. P., Lederberg, A. R., Easterbrooks, S. R., Miller, E. M., & Connor, C. M. (2009). Building the alphabetic principle in young children who are deaf or hard of hearing. *The Volta Review, 109,* 87–119.

Blamey, P. J., Sarant, J. Z., Paatsch, L. E., Barry, J. G., Bow, C. P., Wales, R. J., . . . Tooher, R. (2001). Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. *Journal of Speech, Language, and Hearing Research, 44,* 264–285. doi:10.1044/1092-4388(2001/022)

Bochner, J. H., & Bochner, A. M. (2009). A limitation on reading as a source of linguistic input: Evidence from deaf learners. *Reading in a Foreign Language, 21,* 143–158.

Bow, C. P., Blamey, P. J., Paatsch, L. E., & Sarant, J. Z. (2004). The effects of phonological and morphological training on speech perception scores and grammatical judgments in deaf and hard-of-hearing children. *Journal of Deaf Studies and Deaf Education, 9,* 305–314. doi:10.1093/deafed/enh032

Brentari, D. (1998). *A prosodic model of sign language phonology.* Cambridge, MA: MIT Press.

Briscoe, J., Bishop, D. V. M., & Norbury, C. F. (2001). Phonological processing, language, and literacy: A comparison of children with mild-to-moderate sensorineural hearing loss and those with specific language impairment. *Journal of Child Psychology and Psychiatry, 42,* 329–340. doi:10.1111/1469-7610.00726

Cannon, J. E., Easterbrooks, S. R., Gagne, P., & Beal-Alvarez, J. (2011). Improving DHH students' grammar through an individualized software program. *Journal of Deaf Studies and Deaf Education, 16,* 437–457. doi:10.1093/deafed/enr023

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition, 91,* 77–111. doi:10.1016/S0010-0277(03)00164-1

Chamberlain, C., & Mayberry, R. I. (2008). American Sign Language syntactic and narrative comprehension in skilled and less skilled readers: Bilingual and bimodal evidence for the linguistic basis of reading. *Applied Psycholinguistics, 29,* 367–388. doi:10.1017/S014271640808017X

Colin, S., Magnan, A., Ecalle, J., & Leybaert, J. (2007). Relation between deaf children's phonological skills in kindergarten and word recognition performance in first grade. *Journal of Child Psychology and Psychiatry, 48,* 139–146. doi:10.1111/j.1469-7610.2006.01700.x

Conlin, K., Mirus, G. R., Mauk, C., & Meier, R. P. (2000). Acquisition of first signs: Place, handshape, and movement. In C. Chamberlain, J. Morford, & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 51–69). Mahwah, NJ: Erlbaum.

Connor, C. M., Heiber, S., Arts, H. A., & Zwolan, T. A. (2000). Speech, vocabulary, and the education of children using cochlear implants: Oral or total communication? *Journal of Speech, Language, and Hearing Research, 43,* 1185–1204.

Connor, C. M., & Zwolan, T. A. (2004). Examining multiple sources of influence on the reading comprehension skills of children who use cochlear implants. *Journal of Speech, Language, and Hearing Research, 47,* 509–526. doi:10.1044/1092-4388(2004/040)

Convertino, C. M., Marschark, M., Sapere, P., Sarchet, T., & Zupan, M. (2009). Predicting academic success among deaf college students. *Journal of Deaf Studies and Deaf Education, 14,* 324–343. doi:10.1093/deafed/enp005

Courtin, C. (2000). The impact of sign language on the cognitive development of deaf children: The case of theories of mind. *Journal of Deaf Studies and Deaf Education, 5,* 266–276. doi:10.1093/deafed/5.3.266

Culpepper, B. (2003). Identification of permanent childhood hearing loss through universal newborn hearing screening programs. In B. Bodner-Johnson & M. Sass-Lehrer (Eds.), *The young deaf or hard of hearing child* (pp. 99–126). Baltimore, MD: Brookes.

DeLana, M., Gentry, M. A., & Andrews, J. (2007). The efficacy of ASL/English bilingual education: Considering public schools. *American Annals of the Deaf, 152,* 73–87. doi:10.1353/aad.2007.0010

Dettman, S., & Dowell, R. (2010). Language acquisition and critical periods for children using cochlear implants. In M. Marshark & P. E. Spencer (Eds.), *The Oxford handbook of deaf studies, language, and education* (Vol. 2, pp. 331–342). New York, NY: Oxford University Press.

Easterbrooks, S. R., Lederberg, A. R., Miller, E. M., Bergeron, J. P., & Connor, C. M. (2008). Emergent literacy skills during early childhood in children with hearing loss: Strengths and weaknesses. *The Volta Review, 108,* 91–114.

Edwards, L., Figueras, B., Mellanby, J., & Langdon, D. (2011). Verbal and spatial analogical reasoning in deaf and hearing children: The role of grammar and vocabulary. *Journal of Deaf Studies and Deaf Education, 16,* 189–197. doi:10.1093/deafed/enq051

Ertmer, D. J., & Goffman, L. (2011). Speech production accuracy and variability in young cochlear implant recipients: Comparisons with typically developing age-peers. *Journal of Speech, Language, and Hearing Research, 54,* 177–189. doi:10.1044/1092-4388(2010/09-0165)

Fenson, L., Dale, P. S., Reznick, J. S., & Bates, E. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59,* 1–173. doi:10.2307/1166093

Fischer, S. D., & van der Hulst, H. (2011). Sign language structures. In M. Marscharck & P. E. Spencer (Eds.), *The Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 336–349). New York, NY: Oxford University Press.

Fitzpatrick, E. M., Crawford, L., Ni, A., & Durieux-Smith, A. (2011). A descriptive analysis of language and speech skills in 4- to 5-yr-old children with hearing loss. *Ear and Hearing, 32,* 605–616. doi:10.1097/AUD.0b013e31821348ae

Friedmann, N., & Szterman, R. (2011). The comprehension and production of Wh-questions in deaf and hard-of-hearing children. *Journal of Deaf Studies and Deaf Education, 16,* 212–235. doi:10.1093/deafed/enq052

Furth, H. G. (1966). *Thinking without language: Psychological implications of deafness.* New York, NY: Free Press.

Gallaudet Research Institute. (2001). *Regional and national summary report of data from the 1999–2000 Annual Survey of Deaf and Hard of Hearing Children and Youth.* Washington, DC: Author.

Gallaudet Research Institute. (2008). *Regional and national summary report of data from the 2007–2008 Annual Survey of Deaf and Hard of Hearing Children and Youth.* Washington, DC: Author.

Gaustad, M. G., & Kelly, R. R. (2004). The relationship between reading achievement and morphological word analysis in deaf and hearing students matched for reading level. *Journal of Deaf Studies and Deaf Education, 9,* 269–285. doi:10.1093/deafed/enh030

Gee, J. P., & Mounty, J. L. (1991). Nativization, variability, and style shifting in the sign language development of deaf children of hearing parents. In P. Siple & S. D. Fischer (Eds.), *Theoretical issues in sign language research: Vol. 2, Psychology* (pp. 65–83). Chicago, IL: University of Chicago Press.

Geers, A. E. (2003). Predictors of reading skill development in children with early cochlear implantation. *Ear and Hearing, 24,* 59S–68S. doi:10.1097/01.AUD.0000051690.43989.5D

Geers, A. E. (2006). Spoken language in children with cochlear implants. In P. E. Spencer & M. Marschark (Eds.), *Advances in the spoken language development of deaf and hard-of-hearing children* (pp. 244–270). New York, NY: Oxford University Press.

Geers, A. E., & Hayes, H. (2011). Reading, writing, and phonological processing skills of adolescents with 10 or more years of cochlear implant experience. *Ear and Hearing, 32,* 49S–59S. doi:10.1097/AUD.0b013e3181fa41fa

Geers, A. E., Moog, J. S., Biedenstein, J., Brenner, C., & Hayes, H. (2009). Spoken language scores of children using cochlear implants compared to hearing age-mates at school entry. *Journal of Deaf Studies and Deaf Education, 14,* 371–385. doi:10.1093/deafed/enn046

Geers, A. E., Nicholas, J. G., & Sedey, A. L. (2003). Language skills of children with early cochlear implantation. *Ear and Hearing, 24,* 46S–58S. doi:10.1097/01.AUD.0000051689.57380.1B

Geers, A. E., & Sedey, A. L. (2011). Language and verbal reasoning skills in adolescents with 10 or more years of cochlear implant experience. *Ear and Hearing, 32,* 39S–48S. doi:10.1097/AUD.0b013e3181fa41dc

Geers, A. E., Spehar, B., & Sedey, A. (2002). Use of speech by children from total communication programs who wear cochlear implants. *American Journal of Speech-Language Pathology, 11,* 50–58. doi:10.1044/1058-0360(2002/006)

Gibbs, S. (2004). The skills in reading shown by young children with permanent and moderate hearing impairment. *Educational Research, 46,* 17–27. doi:10.1080/0013188042000178791

Goldin-Meadow, S., & Mayberry, R. I. (2001). How do profoundly deaf children learn to read? *Learning Disabilities Research & Practice, 16,* 222–229. doi:10.1111/0938-8982.00022

Haptonstall-Nykaza, T. S., & Schick, B. (2007). The transition from fingerspelling to English print: Facilitating English decoding. *Journal of Deaf Studies and Deaf Education, 12,* 172–183. doi:10.1093/deafed/enm003

Harkins, J. E., & Bakke, M. (2011). Technologies for communication: Status and trends. In M. Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 425–438). New York, NY: Oxford University Press.

Harris, M., & Moreno, C. (2006). Speech reading and learning to read: A comparison of 8-year-old profoundly deaf children with good and poor reading ability. *Journal of Deaf Studies and Deaf Education, 11,* 189–201. doi:10.1093/deafed/enj021

Harris, M., & Terlektsi, E. (2011). Reading and spelling abilities of deaf adolescents with cochlear implants and hearing aids. *Journal of Deaf Studies and Deaf Education, 16,* 24–34. doi:10.1093/deafed/enq031

Hayes, H., Geers, A. E., Treiman, R., & Moog, J. S. (2009). Receptive vocabulary development in deaf children with cochlear implants: Achievement in an intensive auditory-oral educational setting. *Ear and Hearing, 30,* 128–135. doi:10.1097/AUD.0b013e3181926524

Hermans, D., Knoors, H., Ormel, E., & Verhoeven, L. (2008). The relationship between the reading and signing skills of deaf children in bilingual education programs. *Journal of Deaf Studies and Deaf Education, 13,* 518–530. doi:10.1093/deafed/enn009

Hermans, D., Knoors, H., & Verhoeven, L. (2010). Assessment of sign language development: The case of deaf children in the Netherlands. *Journal of Deaf Studies and Deaf Education, 15,* 107–119. doi:10.1093/deafed/enp030

Hermans, D., Ormel, E., & Knoors, H. (2010). On the relation between the signing and reading skills of deaf bilinguals. *International Journal of Bilingual Education and Bilingualism, 13,* 187–199. doi:10.1080/13670050903474093

Hirsh-Pasek, K. (1987). The metalinguistics of fingerspelling: An alternate way to increase reading vocabulary in congenitally deaf readers. *Reading Research Quarterly, 22,* 455–474. doi:10.2307/747702

Hoffmeister, R. (2000). A piece of the puzzle: ASL and reading comprehension in deaf children. In C. Chamberlain, J. Morford, & R. Mayberry (Eds.), *Language acquisition by eye* (pp. 143–163.). Mahwah, NJ: Erlbaum.

Holzrichter, A. S., & Meier, R. P. (2000). Child-directed signing in American Sign Language. In C. Chamberlain, J. P. Morford, & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 25–40). Mahwah, NJ: Erlbaum.

Hyde, M., & Punch, R. (2011). The modes of communication by children with cochlear implants and the role of sign in their lives. *American Annals of the Deaf, 155,* 535–549. doi:10.1353/aad.2011.0006

Inscoe, J. R., Odell, A., Archbold, S., & Nikolopoulos, T. (2009). Expressive spoken language development in deaf children with cochlear implants who are beginning formal education. *Deafness & Education International, 11,* 39–55.

James, D., Rajput, K., Brinton, J., & Goswami, U. (2008). Phonological awareness, vocabulary, and word reading in children who use cochlear implants: Does age of implantation explain individual variability in performance outcomes and growth? *Journal of Deaf Studies and Deaf Education, 13,* 117–137. doi:10.1093/deafed/enm042

Johnson, C., & Goswami, U. (2010). Phonological awareness, vocabulary, and reading in deaf children with cochlear implants. *Journal of Speech, Language, and Hearing Research, 53,* 237–261. doi:10.1044/1092-4388(2009/08-0139)

Johnson, R., Liddell, S., & Erting, C. J. (1989). *Unlocking the curriculum: Principles for achieving access in deaf education* (Gallaudet Research Institute Working Paper 89-3). Washington, DC: Gallaudet University.

Kelly, L. (1996). The interaction of syntactic competence and vocabulary during reading by deaf students. *Journal of Deaf Studies and Deaf Education, 1,* 75–90. doi:10.1093/oxfordjournals.deafed.a014283

Klima, E., & Bellugi, U. (1979). *The signs of language.* Cambridge, MA: Harvard University Press.

Koehlinger, K. M., Van Horne, A. J., & Moeller, M. P. (2011). *Grammatical outcomes of 3- and 6-year-old children who are hard of hearing.* Manuscript submitted for publication.

Koo, D., Crain, K., LaSasso, C., & Eden, G. F. (2008). Phonological awareness and short-term memory in hearing and deaf individuals of different communication backgrounds. In G. F. Eden & D. L. Flowers (Eds.), *Learning, skill acquisition, reading, and dyslexia* (pp. 83–99). Hoboken, NJ: Wiley-Blackwell.

Kyle, F. E., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children. *Journal of Deaf Studies and Deaf Education, 11,* 273–288. doi:10.1093/deafed/enj037

Lane, H., Hoffmeister, R., & Behan, B. (1996). *A journey into the deaf-world.* San Diego, CA: Dawn Sign Press.

LaSasso, C., Crain, K., & Leybaert, J. (2010). *Cued speech and cued language for deaf and hard of hearing children.* San Diego, CA: Plural.

Lederberg, A. R., & Beal-Alvarez, J. (2011). Expressing meaning: From communicative intent to building vocabulary. In M. Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 258–275). New York, NY: Oxford University Press.

Lederberg, A. R., & Everhart, V. S. (1998). Communication between deaf children and their hearing mothers: The role of language, gesture, and vocalizations. *Journal of Speech, Language, and Hearing Research, 41,* 887–899.

Lederberg, A. R., & Spencer, P. E. (2009). Word-learning abilities in deaf and hard-of-hearing preschoolers: Effect of lexicon size and language modality. *Journal of Deaf Studies and Deaf Education, 14,* 44–62. doi:10.1093/deafed/enn021

Leigh, J., Dettman, S., Dowell, R., & Sarant, J. (2011). Evidence-based approach for making cochlear implant recommendations for infants with residual hearing. *Ear and Hearing, 32,* 313–322. doi:10.1097/AUD.0b013e3182008b1c

Maller, S., Singleton, J., Supalla, S., & Wix, T. (1999). The development and psychometric properties of the American Sign Language Proficiency Assessment (ASL-PA). *Journal of Deaf Studies and Deaf Education, 4,* 249–269. doi:10.1093/deafed/4.4.249

Mayberry, R. I. (1993). First-language acquisition after childhood differs from second-language acquisition: The case of American Sign Language. *Journal of Speech and Hearing Research, 36,* 1258–1270.

Mayberry, R. I. (2010). Early language acquisition and adult language ability: What sign language reveals about the critical period for language. In M. Marshark & P. E. Spencer (Eds.), *The Oxford handbook of deaf studies, language, and education* (Vol. 2, pp. 281–291). New York, NY: Oxford University Press.

Mayberry, R. I., del Giudice, A. A., & Lieberman, A. M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *Journal of Deaf Studies and Deaf Education, 16,* 164–188. doi:10.1093/deafed/enq049

Mayer, C., & Akamatsu, C. T. (2011). Bilingualism and literacy. In M.

Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 144–155). New York, NY: Oxford University Press.

Mayer, C., & Leigh, G. (2010). The changing context for sign bilingual education programs: Issues in language and the development of literacy. *International Journal of Bilingual Education and Bilingualism, 13,* 175–186. doi:10.1080/13670050903474085

Mayne, A. M., Yoshinaga-Itano, C., Sedey, A. L., & Carey, A. (1999). Expressive vocabulary development of infants and toddlers who are deaf or hard of hearing. *The Volta Review, 100,* 1–28.

Meadow-Orlans, K. P., Spencer, P. E., & Koester, L. S. (2004). *The world of the deaf infant: A longitudinal study.* doi:10.1093/acprof:oso/9780195147902.001.0001

Meier, R. P., & Newport, E. L. (1990). Out of the hands of babes: On a possible sign advantage in language acquisition. *Language, 66,* 1–23. doi:10.2307/415277

Meier, R. P., & Willerman, R. (1995). Prelinguistic gesture in deaf and hearing infants. In K. Emmorey & J. Reilly (Eds.), *Language, gesture, and space* (pp. 391–409). Hillsdale, NJ: Erlbaum.

Meristo, M., Falkman, K. W., Hjelmquist, E., Tedoldi, M., Surian, L., & Siegal, M. (2007). Language access and theory of mind reasoning: Evidence from deaf children in bilingual and oralist environments. *Developmental Psychology, 43,* 1156–1169. doi:10.1037/0012-1649.43.5.1156

Meronen, A., & Ahonen, T. (2008). Individual differences in sign language abilities in deaf children. *American Annals of the Deaf, 152,* 495–504. doi:10.1353/aad.2008.0015

Milligan, K., Astington, J. W., & Dack, L. A. (2007). Language and theory of mind: Meta-analysis of the relation between language ability and false-belief understanding. *Child Development, 78,* 622–646. doi:10.1111/j.1467-8624.2007.01018.x

Mitchell, R. E., & Karchmer, M. A. (2004). Chasing the mythical ten percent. *Sign Language Studies, 4,* 138–163. doi:10.1353/sls.2004.0005

Moeller, M. P. (2000). Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics, 106,* e43.

Moeller, M. P., Hoover, B., Putman, C., Arbataitis, K., Bohnenkamp, G., Peterson, B., . . . Stelmachowicz, P. (2007). Vocalizations of infants with hearing loss compared with infants with normal hearing: Part II—Transition to words. *Ear and Hearing, 28,* 628–642. doi:10.1097/AUD.0b013e31812564c9

Moeller, M. P., & Schick, B. (2006). Relations between maternal input and theory of mind understanding in deaf children. *Child Development, 77,* 751–766. doi:10.1111/j.1467-8624.2006.00901.x

Moeller, M. P., Tomblin, J. B., Yoshinaga-Itano, C., Connor, C. M., & Jerger, S. (2007). Current state of knowledge: Language and literacy of children with hearing impairment. *Ear and Hearing, 28,* 740–753. doi:10.1097/AUD.0b013e318157f07f

Moores, D. F. (2010). The history of language and communication issues in deaf education. In M. Marshark & P. E. Spencer (Eds.), *The Oxford handbook of deaf studies, language, and education* (Vol. 2, pp. 17–30). New York, NY: Oxford University Press.

Moores, D. F., & Sweet, C. A. (1990a). Reading and writing skills in deaf adolescents. *International Journal of Rehabilitation Research, 13,* 178–179. doi:10.1097/00004356-199006000-00011

Moores, D. F., & Sweet, C. A. (1990b). Relationships of English grammar and communicative fluency to reading in deaf adolescents. *Exceptionality, 1,* 97–106. doi:10.1080/09362839009524746

Morford, J. P., Wilkinson, E., Villwock, A., Pinar, P., & Kroll, J. F. (2011). When deaf signers read English: Do written words activate their sign translations? *Cognition, 118,* 286–292. doi:10.1016/j.cognition.2010.11.006

Morgan, G., Herman, R., Barriere, I., & Woll, B. (2008). The onset and mastery of spatial language in children acquiring British Sign Language. *Cognitive Development, 23,* 1–19. doi:10.1016/j.cogdev.2007.09.003

Morgenstern, A., Caët, S., Collombel-Leroy, M., Limousin, F., & Blondel, M. (2010). From gesture to sign and from gesture to word: Pointing in deaf and hearing children. *Gesture, 10,* 172–202. doi:10.1075/gest.10.2-3.04mor

Most, T., Levin, I., & Sarsour, M. (2008). The effect of modern standard Arabic orthography on speech production by Arab children with hearing loss. *Journal of Deaf Studies and Deaf Education, 13,* 417–431. doi:10.1093/deafed/enm060

Musselman, C. (2000). How do children who can't hear learn to read an alphabetic script? A review of the literature on reading and deafness. *Journal of Deaf Studies and Deaf Education, 5,* 9–31. doi:10.1093/deafed/5.1.9

Musselman, C., & Akamatsu, C. T. (1999). Interpersonal communication skills of deaf adolescents and their relationship to communication history. *Journal of Deaf Studies and Deaf Education, 4,* 305–320. doi:10.1093/deafed/4.4.305

National Center for Hearing Assessment and Management. (2011). *Early hearing detection and intervention components.* Retrieved from http://www.infanthearing.org/components/

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science, 14,* 11–28. doi:10.1207/s15516709cog1401_2

Nicholas, J. G., & Geers, A. E. (2006). The process and early outcomes of cochlear implantation by three years of age. In P. E. Spencer & M. Marschark (Eds.), *Advances in the spoken language development of deaf children* (pp. 271–297). doi:10.1093/acprof:oso/9780195179873.003.0012

Nicodemus, B. (2008). The use of prosodic markers to indicate utterance boundaries in American Sign Language interpretation. *Sign Language & Linguistics, 11,* 113–122. doi:10.1075/sl&l.11.1.16nic

Niparko, J. K., Tobey, E. A., Thal, D. J., Eisenberg, L. S., Wang, N.-Y., Quittner, A. L., & Fink, N. E. (2010). Spoken language development in children following cochlear implantation. *The Journal of the American Medical Association, 303,* 1498–1506. doi:10.1001/jama.2010.451

Nittrouer, S. (2010). *Early development of children with hearing loss.* San Diego, CA: Plural.

Nott, P., Cowan, R., Brown, P. M., & Wigglesworth, G. (2009). Early language development in children with profound hearing loss fitted with a device at a young age: Part I—The time period taken to acquire first words and first word combinations. *Ear and Hearing, 30,* 526–540. doi:10.1097/AUD.0b013e3181a9ea14

Nunes, T., Burman, D., Evans, D., & Bell, D. (2010). Writing a language that you can't hear. In N. Brunswick, S. McDougall, & P. de Mornay Davies (Eds.), *Reading and dyslexia in different orthographies* (pp. 109–128). New York, NY: Psychology Press.

Padden, C. A., & Ramsey, C. (2000). American Sign Language and reading ability in deaf children. In C. Chamberlain, J. P. Morford, & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 165–189). Mahwah, NJ: Erlbaum.

Perfetti, C. A., & Sandak, R. (2000). Reading optimally builds on spoken language: Implications for deaf readers. *Journal of Deaf Studies and Deaf Education, 5,* 32–50. doi:10.1093/deafed/5.1.32

Peterson, C. C., Wellman, H. M., & Liu, D. (2005). Steps in theory-of-mind development for children with deafness or autism. *Child Development, 76,* 502–517. doi:10.1111/j.1467-8624.2005.00859.x

Petitto, L. A. (1987). On the autonomy of language and gesture: Evidence from the acquisition of personal pronouns in American Sign Language. *Cognition, 27,* 1–52. doi:10.1016/0010-0277(87)90034-5

Petitto, L. A., Holowka, S., Sergio, L. E., & Ostry, D. (2001, September 6). Language rhythms in baby hand movements. *Nature, 413,* 35–36. doi:10.1038/35092613

Pizzuto, E. (1990). The early development of deixis in American Sign Language: What is the point? In V. Volterra & C. J. Erting (Eds.), *From gesture to language in hearing and deaf children* (pp. 142–152). doi:10.1007/978-3-642-74859-2_12

Power, D., Hyde, M., & Leigh, G. (2008). Learning English from Signed English: An impossible task? *American Annals of the Deaf, 153,* 37–47. doi:10.1353/aad.0.0008

Preisler, G., Tvingstedt, A. L., & Ahlström, M. (2002). A psychosocial follow-up study of deaf preschool children using cochlear implants. *Child: Care, Health and Development, 28,* 403–418. doi:10.1046/j.1365-2214.2002.00291.x

Prinz, P. M., & Strong, M. (1998). ASL proficiency and English literacy within a bilingual deaf education model of instruction. *Topics in Language Disorders, 18,* 47–60.

Pyman, B., Blamey, P., Lacy, P., Clark, G., & Dowell, R. (2000). The development of speech perception in children using cochlear implants: Effects of etiologic factors and delayed milestones. *The American Journal of Otology, 21,* 57–61.

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001). How psychological science informs the teaching of reading. *Psychological Science in the Public Interest, 2,* 31–74. doi:10.1111/1529-1006.00004

Reitsma, P. (2009). Computer-based exercises for learning to read and spell by deaf children. *Journal of Deaf Studies and Deaf Education, 14,* 178–189. doi:10.1093/deafed/enn031

Remmel, E., & Peters, K. (2009). Theory of mind and language in children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 14,* 218–236. doi:10.1093/deafed/enn036

Schauwers, K., Gillis, S., & Govaerts, P. (2005). Language acquisition in children with a cochlear implant. In P. Fletcher & J. F. Miller (Eds.), *Developmental theory and language disorders* (pp. 95–120). Philadelphia, PA: John Benjamins.

Schauwers, K., Gillis, S., & Govaerts, P. J. (2008). The characteristics of prelexical babbling after cochlear implantation between 5 and 20 months of age. *Ear and Hearing, 29,* 627–637. doi:10.1097/AUD.0b013e318174f03c

Schembri, A. (2003). Rethinking "classifiers" in signed languages. In K. Emmorey (Ed.), *Perspectives on classifier constructions in sign language* (pp. 3–34). Mahwah, NJ: Erlbaum.

Schick, B. (1990a). Classifier predicates in American Sign Language. *International Journal of Sign Linguistics, 1,* 15–40.

Schick, B. (1990b). The effects of morphosyntactic structure on the acquisition of classifier predicates in ASL. In C. Lucas (Ed.), *Sign language research: Theoretical issues* (pp. 358–374). Washington, DC: Gallaudet University Press.

Schick, B. (2002). The expression of grammatical relations in deaf toddlers learning ASL. In B. Woll & G. Morgan (Eds.), *An international perspective on the acquisition of sign languages* (pp. 143–158). Philadelphia, PA: John Benjamins.

Schick, B. (2011). The development of American Sign Language and Manually Coded English systems. In M. Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 229–240). New York, NY: Oxford University Press.

Schick, B., de Villiers, P., de Villiers, J., & Hoffmeister, R. (2007). Language and theory of mind: A study of deaf children. *Child Development, 78,* 376–396. doi:10.1111/j.1467-8624.2007.01004.x

Schick, B., Marschark, M., & Spencer, P. E. (Eds.). (2006). *Advances in the sign language development of deaf children.* New York, NY: Oxford University Press.

Schick, B., & Moeller, M. P. (1992). What is learnable in manually coded English sign systems? *Applied Psycholinguistics, 13,* 313–340. doi:10.1017/S014271640000566X

Senghas, A., & Coppola, M. (2001). Children creating language: How Nicaraguan Sign Language acquired a spatial grammar. *Psychological Science, 12,* 323–328. doi:10.1111/1467-9280.00359

Sharma, A., Nash, A. A., & Dorman, M. (2009). Cortical development, plasticity and re-organization in children with cochlear implants. *Journal of Communication Disorders, 42,* 272–279. doi:10.1016/j.jcomdis.2009.03.003

Siedlecki, T., Votaw, M. C., Bonvillian, J. D., & Jordan, I. K. (1990). The effects of manual interference and reading level on deaf subjects' recall of word lists. *Applied Psycholinguistics, 11,* 185–199. doi:10.1017/S0142716400008766

Singleton, J. L., & Newport, E. L. (2004). When learners surpass their models: The acquisition of American Sign Language from inconsistent input. *Cognitive Psychology, 49,* 370–407. doi:10.1016/j.cogpsych.2004.05.001

Singleton, J. L., Supalla, S., Litchfiled, S., & Schley, S. (1998). From sign to word: Considering modality constraints in ASL/English bilingual education. *Topics in Language Disorders, 18,* 16–29.

Spencer, L. J., & Tomblin, J. B. (2009). Evaluating phonological processing skills in children with prelingual deafness who use cochlear implants. *Journal of Deaf Studies and Deaf Education, 14,* 1–21. doi:10.1093/deafed/enn013

Spencer, L. J., Tye-Murray, N., & Tomblin, J. B. (1998). The production of English inflectional morphology, speech production and listening performance in children with cochlear implants. *Ear and Hearing, 19,* 310–318. doi:10.1097/00003446-199808000-00006

Spencer, P. E. (2004). Individual differences in language performance after cochlear implantation at one to three years of age: Child, family, and linguistic factors. *Journal of Deaf Studies and Deaf Education, 9,* 395–412. doi:10.1093/deafed/enh033

Spencer, P. E., & Harris, M. (2006). Patterns and effects of language input to deaf infants and toddlers from deaf and hearing mothers. In B. Schick, M. Marschark, & P. E. Spencer (Eds.), *Advances in the sign language development of deaf children* (pp. 71–101). New York, NY: Oxford University Press.

Spencer, P. E., & Lederberg, A. R. (1997). Different modes, different models: Communication and language of young deaf children and their mothers. In L. B. Adamson & M. A. Romski (Eds.), *Research on communication and language disorders: Contributions to theories of language development* (pp. 203–230). Baltimore, MD: Brookes.

Spencer, P. E., & Marschark, M. (2010). *Evidence-based practice in education deaf and hard-of-hearing students.* New York, NY: Oxford University Press.

Spencer, P. E., Marschark, M., & Spencer, L. J. (2011). Cochlear implants: Advances, issues, and implications. In M. Marschark & P. E. Spencer (Eds.), *The Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 452–472). New York, NY: Oxford University Press.

Stokoe, W., Casterline, D., & Croneberg, C. (1965). *A dictionary of American Sign Language on linguistic principles.* Washington, DC: Gallaudet University Press.

Strong, M., & Prinz, P. M. (1997). A study of the relationship between American Sign Language and English literacy. *Journal of Deaf Studies and Deaf Education, 2,* 37–46. doi:10.1093/oxfordjournals.deafed.a014308

Supalla, S. J. (1991). Manually-Coded English: The modality question in signed language development. In P. Siple & S. D. Fischer (Eds.), *Theoretical issues in sign language research* (Vol. 2, pp. 85–109). Chicago, IL: University of Chicago Press.

Supalla, T. (1986). The classifier system in American Sign Language. In C. Craig (Ed.), Noun classes and categorization (pp. 181–212). Philadelphia, PA: John Benjamins.

Svartholm, K. (2010). Bilingual education for deaf children in Sweden. *International Journal of Bilingual Education and Bilingualism, 13,* 159–174. doi:10.1080/13670050903474077

Szagun, G. (2004). Learning by ear: On the acquisition of case and gender marking by German-speaking children with normal nearing and with cochlear implants. *Journal of Child Language, 31,* 1–30. doi:10.1017/S0305000903005889

Szameitat, S., & Schick, B. (2010, September–October). *Systematic phonological errors in the acquisition of ASL by native-signing Deaf children.* Paper presented at the Theoretical Issues in Sign Language Research Conference (TISLR 10), West Lafayette, IN.

Tobey, E. A., Geers, A. E., Brenner, C., Altuna, D., & Gabbert, G. (2003). Factors associated with development of speech production skills in children implanted by age five. *Ear and Hearing, 24,* 36S–45S. doi:10.1097/01.AUD.0000051688.48224.A6

Tomblin, J. B., Barker, B. A., Spencer, L. J., Zhang, X., & Gantz, B. J. (2005). The effect of age at cochlear implant initial stimulation on expressive language growth in infants and toddlers. *Journal of Speech, Language, and Hearing Research, 48,* 853–867. doi:10.1044/1092-4388(2005/059)

Traxler, C. B. (2000). The Stanford Achievement Test, 9th Edition: National norming and performance standards for deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education, 5,* 337–348. doi:10.1093/deafed/5.4.337

Wang, Y., Trezek, B. J., Luckner, J. L., & Paul, P. V. (2008). The role of phonology and phonologically related skills in reading instruction for students who are deaf or hard of hearing. *American Annals of the Deaf, 153,* 396–407. doi:10.1353/aad.0.0061

Watson, L. M., Archbold, S. M., & Nikolopoulos, T. P. (2006). Children's communication mode five years after cochlear implantation: Changes over time according to age at implant. *Cochlear Implants International, 7,* 77–91. doi:10.1002/cii.301

Waxman, R., & Spencer, P. (1997). What mothers do to support infant visual attention: Sensitivities to age and hearing status. *Journal of Deaf Studies and Deaf Education, 2,* 104–114. doi:10.1093/oxfordjournals.deafed.a014311

Webb, M., & Lederberg, A. R. (2012). *Measuring phonological awareness in deaf and hard of hearing children.* Manuscript submitted for publication.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development, 72,* 655–684. doi:10.1111/1467-8624.00304

Wilbur, R. B. (2011). Modality and the structure of language: Sign languages versus signed systems. In M. Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (2nd ed., Vol. 1, pp. 350–366). New York, NY: Oxford University Press.

Wilcox, S. (1992). *The phonetics of fingerspelling.* Philadelphia, PA: John Benjamins.

Woolfe, T., Herman, R., Roy, P., & Woll, B. (2010). Early vocabulary development in deaf native signers: A British Sign Language adaptation of the Communicative Development Inventories. *Journal of Child Psychology and Psychiatry, 51,* 322–331. doi:10.1111/j.1469-7610.2009.02151.x

Woolfe, T., Want, S. C., & Siegal, M. (2002). Signposts to development: Theory of mind in deaf children. *Child Development, 73,* 768–778. doi:10.1111/1467-8624.00437

Yang, J. H. (2008). Sign language and oral/written language in deaf education in China. In C. Plaza-Pust & E. Morales-Lopes (Eds.), *Sign bilingualism: Language development, interaction and maintenance in sign language contact situations* (pp. 297–331). Amsterdam, the Netherlands: John Benjamins.

Yoshinaga-Itano, C., & Sedey, A. L. (1998). Language of early- and later-identified children with hearing loss. *Pediatrics, 102,* 1161–1171. doi:10.1542/peds.102.5.1161

Received June 3, 2011
Revision received April 18, 2012
Accepted April 20, 2012 ■