

Spoken Language Development in Infants who are Deaf or Hard of Hearing: The Role of Maternal Infant-Directed Speech

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How do children learn spoken language? Most children with typical hearing learn from infancy the sound of their mother's voice, a type of speech researchers call infant-directed speech. Mothers, fathers and most adults speak to infants in a sing-song manner, exaggerating the melody and rhythm of their speech. But what happens when this connection is broken, such as with a child who has hearing loss? This article will discuss the importance of infant-directed speech, and how infants with hearing loss respond to such talk in comparison to infants with typical hearing.

How do children learn spoken language? In children who are developing typically, this feat is accomplished more or less naturally through active experiences with caregivers and the child's environment. Parents don't enroll infants and toddlers in spoken language classes; instead, they model, encourage, and stimulate their speech and language attempts by responding to the cries and coos of infants and holding simple conversations with toddlers. In fact, caregivers across the world actually speak to their infants and young children using a special style of speech commonly known as "babytalk" or "motherese." Researchers and scholars call this *infant-directed speech*. Mothers, fathers, and even strangers off the streets speak to infants in a sing-song manner, exaggerating the melody and rhythm of their speech (e.g., Ferguson, 1964; Fernald, 1989). Caregivers are flexible with this speech style, adjusting the levels of exaggeration according to the social context and their infant's age (e.g., Kitamura, Thanavishuth, Burnham, & Luksaneeyanawin, 2002; Stern, Spieker, Barnett, & MacKain, 1983). This speech style is now known to contribute in many ways not only to infants' social-emotional development, but also to their speech, language, and cognitive development (e.g., Liu, Kuhl, & Tsao, 2003).

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Sometimes that natural connection between caregivers and infants can be disrupted. For example, caregivers who suffer from depression have difficulty connecting with their children, speaking to them in monotones with flat affect. Researchers have shown that infants of mothers who are depressed have a difficult time learning new associations from such speech (Kaplan, Bachorowski, Smoski, & Hudenko, 2002), which likely has cascading effects on the development of spoken language and cognition. Moreover, children in families with low socioeconomic status are at a serious disadvantage compared to children in families with high socioeconomic status in terms of both spoken language input quantity and quality. Researchers have found that caregivers with fewer financial and educational resources use fewer words in their infant- and child-directed speech than caregivers with greater financial and educational resources (Hart & Risley, 1995). This effect later translates to language abilities, with children from low income homes exhibiting much worse language skills compared to children from high income homes (Hart & Risely, 1995). These studies, among others, highlight the importance of caregivers' speech to infants as they develop spoken language.

What happens, then, if infants have a hard time hearing their caregivers? How do children who are deaf or hard of hearing learn spoken language? With the advent of new technologies, such as cochlear implants and state-of-the-art hearing aids, children with hearing loss now have the most access to sound and spoken language in their environment than ever before. Because of this, we would expect caregivers to speak to their infants and children with hearing loss just the same as those with typical hearing. And children with hearing loss who use hearing aids or cochlear implants should demonstrate similar spoken language development as children with typical hearing. Children who are deaf or hard of hearing *can* achieve speech and spoken language abilities on par with their typically developing peers with the use of such assistive devices (e.g., Peterson, Pisoni, & Miyamoto, 2010). However, there are large individual differences among these children; not all children with hearing loss benefit to the same degree from cochlear implants or hearing aids (Pisoni, Cleary, Geers, & Tobey, 1999; Pisoni et al., 2008). As recently as 10 years ago, researchers could only guess at why this is the case because there were no pre-amplification predictors of outcome and benefit. However, recent studies have shown potential predictors of children who will succeed with hearing aids or cochlear implants that are related to early auditory experience (e.g., Bergeson & Pisoni, 2004).

Child Perception of Infant-Directed Speech

The focus of this paper is one of the most important factors that can determine infants' benefit and success in spoken language development via amplification: early auditory experiences from infants' interactions with their caregivers, or infant-directed speech. The first question addressed is, do infants

who have hearing loss for the first part of their life pay the same kind of attention to infant-directed speech as infants with typical hearing do? This is one way to determine if infants with hearing loss are reinforcing caregivers' use of infant-directed speech.

To answer this question, let's first review what is known about infant attention to maternal speech in typical development. At least two types of infant behaviors have been established by researchers. First, infants with typical hearing, from birth to 12 months old, prefer to listen to infant-directed speech over adult-directed speech (Fernald & Simon, 1984; Fernald et al., 1989; Grieser & Kuhl, 1988; Kitamura et al., 2002; Kuhl et al., 1997). Infants are especially responsive to the melodic quality of infant-directed speech (Fernald & Kuhl, 1987). Infants' increased attention to infant-directed speech might actually help them process and understand speech and language. For example, infants find it easier to pick out new words from a spoken passage when listening to infant-directed speech rather than adult-directed speech (Thiessen, Hill, & Saffran, 2005). Mothers tend to highlight new words when speaking to infants much more so than when speaking to adults.

Second, infants with typical hearing recognize and prefer to listen to their own mothers' voice (DeCasper & Fifer, 1980). Amazingly, preference for maternal voices seems to develop even before infants are born. One study found that infants in the womb have different heart rate patterns in response to their mother's voice as compared to a stranger's voice (Kisilevsky et al., 2003). These findings also highlight the important effects of very early auditory experience on infants' speech perception abilities.

But what about infants and toddlers who have congenital hearing loss and receive hearing aids or cochlear implants? Do they pay the same type of attention to speech as infants with typical hearing? Research from the Babytalk Research Laboratory has been addressing this very question. One of the difficulties of assessing attention in this population is that the research participants are preverbal. That is, we cannot simply ask the infants and toddlers, "What do you think about this speech? Do you like this type of speech better than the other?" Instead, we use tried-and-true methods taken from the field of developmental psychology. Infants sit on their caregivers' laps inside a large sound-proof booth. We draw their attention to a TV monitor in front of them, and then present various audio-visual stimuli. Previous research has shown that infants will naturally look longer towards a visual display near a sound source if they're interested in what they're hearing.

In one particular study, we measured infants' looking time to a red-and-white checkerboard pattern on the TV monitor while listening to four different mothers speaking in either an infant-directed or adult-directed style of speech. The study also included silent trials to determine how much infants prefer speech in general to silence. Infants with typical hearing attended much longer

to speech trials than silent trials, and generally preferred infant-directed to adult-directed speech. Infants with mild-to-moderate hearing loss who use hearing aids showed similar patterns, but it took a little longer for them to develop their preferences than infants with typical hearing. Finally, infants with cochlear implants did not show a preference for infant-directed speech over adult-directed speech until approximately 9-12 months post-implantation. And even then, they did not attend any longer to the adult-directed speech than to silence! These findings have major implications for child-caregiver interactions and spoken language development.

There are some studies about recognition of voices in children who are deaf or hard of hearing. Several studies have shown that cochlear implant users find it difficult to distinguish the voices of different talkers, particularly if the talkers are the same sex (Cleary & Pisoni, 2002; Cleary, Pisoni, & Kirk, 2005; Fu, Chinchilla, & Galvin, 2004). However, one recent study showed that children ages 5-15 years old who use cochlear implants can tell apart their own mother's voice from other men, children, and even other women, although their performance is not as good as that of children with typical hearing (Vongpaisal, Trehub, Schellenberg, van Lieshout, & Papsin, 2010).

The Babytalk Research Laboratory is in the midst of conducting another study to determine whether infants with congenital hearing loss can distinguish their own mother's voice from a stranger's voice. This study uses a habituation paradigm, in which a series of different women reciting passages in an infant-directed speech style is presented to infants who have about one year of hearing aid or cochlear implant experience. The idea is that infants will again pay attention to a checkerboard pattern on the TV monitor directly ahead of them when they are interested in the speech sounds. In a habituation paradigm, it is also expected that infants will start off with a high amount of interest and gradually become bored as the same category of sound (i.e., women's infant-directed speech) is repeated. Two test trials are presented once they reach a criterion point of boredom: one is their own mother's voice and the other is a stranger's voice. If they recognize their mother's voice, infants should theoretically pay more attention than to the last habituation trial and the test trial with the stranger's voice. If they do not recognize their mother's voice, then they should pay equal attention to all three trials. Data have been collected from a handful of infants and toddlers who are deaf or hard of hearing who have used a hearing aid or cochlear implant for approximately one year. These children have not yet shown recognition of their own mother's voice from that of a strange woman. Future studies will likely be needed to determine how infants and toddlers learn to recognize their mother's voice with additional hearing aid or cochlear implant use.

Caregiver Production of Infant-Directed Speech

Thus far, research has shown that infants and young children who are deaf or hard of hearing do not pay attention to infant-directed speech, or even speech in general, in the same way as children with typical hearing until they've had at least 9-12 months of auditory experience. Imagine now parents interacting with infants who are deaf or hard of hearing. If their infants are not paying active attention to their attempts to entertain or soothe using infant-directed speech, how must this affect caregivers' further use of this special speech style? That is, do caregivers speak in the same or different ways to young children with and without hearing loss?

To date there has been very little research on caregiver speech to infants with hearing loss who use hearing aids and cochlear implants. One reason is that, prior to state-mandated universal newborn hearing screening programs, infants were typically not diagnosed with hearing loss until 2-3 years of age (Meadow-Orlans, Spencer, & Koester, 2004). The existing literature suggests that an infant's hearing status may affect the way in which caregivers speak to their infants. One study of speech to infants with hearing loss showed that mothers with typical hearing tend to increase their use of vocal exaggeration when they first discover their infant's hearing loss, but gradually decrease the amount of vocal exaggeration over time (Wedell-Monnig & Lumley, 1980). Other studies of mother-child interactions have revealed that mothers tend to be more controlling, more repetitive, and less responsive in their interactions with children who are deaf or hard of hearing than with children who have typical hearing (Cheskin, 1981; Goss, 1970; Henggeler & Cooper, 1983). Mothers also produce fewer and less complex verbal utterances but more nonverbal attention-getting behaviors when interacting with children with hearing loss than children with typical hearing (Goldin-Meadow & Saltzman, 2000; Koester, Brooks, & Karkowski, 1998; Koester, Karkowski, & Traci, 1998). Some researchers have shown, however, more similarities in mothers' speech styles to both sets of children when the children were matched by linguistic age rather than chronological age (Cross, Nienhuys, & Kirkman, 1985; Nienhuys, Cross, & Horsborough, 1984).

The Babytalk Research Laboratory recently investigated the effects of infant age and hearing loss on several prosodic characteristics of mothers' speech to infants with typical hearing and infants with hearing loss who use cochlear implants (Bergeson, Miller, & McCune, 2006; Kondaurova, Bergeson, & Xu, 2012). The results of these studies revealed that mothers do use infant-directed speech when interacting with their infants with cochlear implants, and that their vocal styles are more similar to mothers of infants with typical hearing when infants are matched by hearing experience rather than chronological age. Thus, these mothers adapt their prosodic speech style to the hearing experience and linguistic abilities of their infants who are deaf or hard of hearing.

Researchers have proposed that one of the functions of infant-directed speech is to help infants learn about language (e.g., Fernald, 1992). For example, infant-directed speech actually exaggerates certain cues to sentence structure. Caregivers will change the pitch of their voice from the end of one sentence to the beginning of another when speaking to an infant. They will also tend to linger on the last syllable of a sentence and take an exaggerated pause before starting a new sentence. In a recent analysis of maternal speech, we found that mothers use similar sentence boundary cues when interacting with their infants who are profoundly deaf and use cochlear implants (Kondaurova & Bergeson, 2011).

Infant-directed speech might also help infants learn about the sound structure of their language. One study found that mothers potentially help their infants with typical hearing and infants with hearing loss discriminate among vowel categories (e.g., "ah," "ee," and "oo") by exaggerating the differences among them (Dilley & Bergeson, 2010). Another study measured mothers' exaggeration of cues that commonly distinguish tense vowels (e.g., "sheep") and lax vowels (e.g., "ship") in their speech to infants with profound hearing loss. There are two cues to this vowel contrast, one of which should be easily encoded with cochlear implant technology (duration of the vowel) and the other which is more problematic for cochlear implant users (spectrum of the vowel). Results showed that mothers exaggerated duration but not spectrum cues in speech to infants with hearing loss compared to speech to adults (Kondaurova, Bergeson, & Dilley, in press).

Taken together, these studies suggest that mothers' speech is sensitive to their young children's linguistic and hearing levels. In other words, mothers seem to be providing their infants and toddlers who are deaf or hard of hearing with speech cues tailored to their individual abilities. These findings are important given previous research that shows that the features of infant-directed speech have significant effects on language and cognitive development (Hart & Risley, 1995; Kaplan et al., 2002; Liu et al., 2003; Meadow-Orlans & Spencer, 1996; Pressman, Pipp-Siegel, Yoshinaga-Itano, & Deas, 1999; Spencer & Meadow-Orlans, 1996).

Nevertheless, there are still several unanswered questions regarding the acquisition of speech and language skills in both populations. Which aspects of infant-directed speech make it particularly beneficial for language acquisition? It could be that infant-directed speech is most beneficial because the vowel/consonant categories are clearer or more exaggerated. Or it could be the case that more general exaggeration (e.g., higher pitch or slower speaking rate) in mothers' speech to infants elicits and maintains infants' attention, which then allows the infants to pay attention to particular sounds or sentence structures.

Moreover, infants with hearing loss may benefit from different features of infant-directed speech than infants with typical hearing. What is the best way for a mother (or a speech-language pathologist) to speak to an infant, and is this the same for infants who use a hearing aid or a cochlear implant? Preliminary data in the Babytalk Research Laboratory shows that some features of mothers' speech to infants with hearing loss, such as use of repetition, is associated with their infants' ability to learn new words and other speech and language outcomes. Answers to these questions will provide valuable new information to parents and clinicians of infants who are deaf or hard of hearing and use hearing aids and cochlear implants.

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