



Vocabulary development in Mandarin-speaking children with cochlear implants and its relationship with speech perception abilities



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ABSTRACT

Background: China has the largest population of children with hearing impairments and cochlear implantation is gaining popularity there. However, the vocabulary development in this population is largely unexplored.

Aims: This study examined early vocabulary outcomes, factors influencing early vocabulary development and the relationship between speech perception and vocabulary development in Mandarin-speaking children during the first year of cochlear implant use.

Methods and procedures: A battery of vocabulary tests was administered to 80 children before implantation and 3, 6, and 12 months after implantation. Demographic information was obtained to evaluate their relationships with vocabulary outcomes.

Outcomes and results: The Mandarin-speaking children, who received their cochlear implants before 3 years of age, developed vocabulary at a rate faster than that of their same-aged peers with normal hearing. Better pre-implant hearing levels, younger age at implantation, and higher maternal education level contributed to the early vocabulary development. The trajectories of speech perception development highly correlated with those of vocabulary development during 3 to 12 months of CI use.

Conclusions and Implications: These findings imply that the vocabulary development of children implanted before 3 years of age may catch up with that of their hearing peers.

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1. Introduction

In 2006, the National Bureau of Statistics of China reported that 27.8 million people suffered from hearing impairment (HI) in Mainland China. Approximately 137,000 of them were children aged 0–6 years of age with severe to profound HI. Cochlear implantation (CI) is widely recognized as a support for spoken language development (Hayes, Geers, Treiman, & Moog, 2009). A dramatic increase in CI is, therefore, expected in mainland China in the immediate future. Just the national donation program alone funded more than 16,000 cochlear implantation surgeries from 2011 to 2015 (Liang & Mason, 2013). Therefore, there is an urgent need to evaluate outcomes of CI in these children.

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In addition to improvement in speech perception, improvement in vocabulary development has been reported among English-speaking children implanted before 2–3 years of age (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Hayes et al., 2009; Nicholas & Geers, 2007). After implantation, the vocabulary development of these children was faster than that of their age-matched peers with hearing aids and paralleled that of children with normal hearing (NH). However, few studies have examined vocabulary development in Mandarin-speaking children with CIs and the vocabulary performance in those children may not be identical to their English-speaking peers considering the social, cultural and linguistic differences among these two populations.

Mandarin is a tonal language, in which tone is lexically meaningful. The fundamental frequency characteristics (i.e., pitch and pitch contour) of a word distinguish lexical meanings among otherwise identical phonemes. A couple of recent studies reported that tone information seems to be redundant for Mandarin speech perception in quiet but particularly important for speech perception in noise among adults with normal hearing (Chen, Wong, & Hu, 2014; Feng, Xu, Zhou, Yang, & Yin, 2012). However, CIs do not explicitly code pitch information, which complicates the issue of speech and vocabulary in Mandarin-speaking children with CIs. The perception of pitch in children with CIs relies on two main mechanisms: place pitch, which is affected by the position of the stimulating electrode as a result of the tonotopic organization of the inner ear, and temporal pitch, which is provided by the rate of stimulation of an electrode (Tan, Dowell, & Vogel, 2016). CI users exhibited a broad range of place-pitch sensitivity (Donaldson, Krefit, & Litvak, 2005) and typically were unable to discriminate between rates greater than 300 Hz, as opposed to a temporal pitch percept up to 4–5 kHz in a healthy cochlea (Moore & Carlyon, 2005). Furthermore, children have greater difficulties in applying knowledge of morphology, syntax and semantics to compensate for the ambiguous cues. Therefore, tone information may be important for Mandarin speech perception both in quiet and in noise for children with CIs (Chen, Wong, Chen, & Xi, 2014).

In Mainland China, due to under-spending on national health care and a large population, there is a lack of hearing health care professionals (fewer than one audiologist per million people), an effective universal newborn hearing screening system and a systematic follow-up process (Liang & Mason, 2013). As a result, intervention is usually not available until children reach 2–3 years of age, and many children had not undergone a hearing aid trial before implantation (Chen et al., 2010; Chen, Wong, Chen et al., 2014). In addition, the majority of parents of children with CIs in mainland China have lower educational levels (middle or high school graduates) compared to their English-speaking peers (high school graduates or above) (Chen, Wong, Chen et al., 2014). Previous studies have shown that late age at implantation, failure to undergo a hearing aid trial before implantation, and low maternal education level are significantly related to poor speech perception in Mandarin-speaking children with CIs (Chen, Wong, Chen et al., 2014; Chen, Wong, Zhu, & Xi, 2015; Chen, Wong, Zhu, & Xi, 2016). These factors may also adversely affect vocabulary development, considering the high correlation between speech perception and vocabulary skills (DesJardin, Ambrose, Martinez, & Eisenberg, 2009).

In contrast, some linguistic and cultural factors may contribute positively to vocabulary development in Mandarin-speaking children. First, compared to English, vowels in Chinese exhibit a much greater contribution to sentence intelligibility (Chen, Wong, & Wong, 2013), and children seem to perceive vowels better and acquire them earlier than consonants (Hua & Dodd, 2000). Thus, early speech perception and vocabulary development in Mandarin-speaking children may follow a course different from that of English-speaking children. Second, the stigma associated with HI as well as the fragmentation of services for individuals with HI in China enhances the desire to “live life in the mainstream” (Liang & Mason, 2013). As a result, the majority of children with CIs in mainland China use the oral mode of communication and attend aural-oral rehabilitation programs after implantation. Children enrolled in oral communication programs demonstrate better spoken language after implantation than children enrolled in total communication programs (Geers, Nicholas, & Sedey, 2003). Third, there is a long Chinese tradition of families investing in the education of their children, which is further enhanced by the one-child policy and economic growth in Mainland China. As children from smaller families tend to exhibit better speech perception skills and language skills (Geers, Brenner, & Davidson, 2003; Geers, Nicholas et al., 2003), these factors together probably contribute to better vocabulary development in Mandarin-speaking children than that in their English-speaking peers.

Although many demographic factors (i.e., earlier age at implantation, longer duration of CI use, smaller family size, oral communication mode) have been found to predict successful implant use in English-speaking children, they accounted for less than half of the variance in vocabulary scores (Geers, Nicholas et al., 2003). Considering the fact that the ability to perceive the sounds of speech is the foundation for spoken language development (DesJardin et al., 2009), it is reasonable to hypothesize that speech perception skills would also explain a significant proportion of variance in vocabulary development in Mandarin-speaking children, as has previously been found among English-speaking children ($r=0.56-0.7$) (Davidson, Geers, Blamey, Tobey, & Brenner, 2011; DesJardin et al., 2009; Eisenberg, Martinez, Holowecy, & Pogorelsky, 2002; Schorr, 2006). Similar studies in younger Mandarin-speaking children with CIs were not possible until recently when standardized vocabulary measures became available (Lu, Wong, Wong, & Xi, 2013).

In summary, the present study served three purposes. First, we examined the vocabulary growth rate in Mandarin-speaking children with CIs and compared the results to those of children with NH from earlier studies. Second, we examined the effects of four demographic factors on vocabulary development. These demographic factors included age at implantation, unaided pure-tone average in the better ear, whether a child had undergone a hearing aid trial before implantation and maternal education level. These factors were chosen because they, in particular the last two, were of clinical interest in the context of mainland China as discussed above. Other demographic factors (i.e., communication mode, absence of other disabilities, unilateral implantation, and cognitive abilities) that might also significantly affect language development in

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