HiRes 120 and Lexical Tone Perception in Mandarin-Speaking Children

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". . .the results of the present study. . . indicate that the temporal and spectral information delivered by HiResolution sound processing may underlie an improved ability to hear tonal contrasts in some of the Mandarin-speaking children."

A fundamental characteristic of tone languages (such as Mandarin Chinese, Thai, and Vietnamese) is that tone patterns in a syllable convey lexical meaning. Lexical tone perception varies dramatically among cochlear implant users who are native tone language speakers, and most adult users have great difficulty distinguishing the tonal contrasts important for understanding speech (e.g., Huang et al, 1995; Sun et al, 1998; Wei et al, 2004). Pediatric implant users also have great difficulties in extracting the pitch information needed to identify the lexical tones (Ciocca et al, 2002; Lee et al, 2002; Wei et al, 2000; Wong and Wong, 2004).

Studies suggest that a greater number of spectral channels might provide the cues that are essential for tone perception (Shannon, 2005). In fact, Xu and others already have shown that spectral cues are important for lexical tone perception and that fine structure cues are essential for lexical tone perception in normal-hearing Mandarin-speaking adults (Xu et al, 2002; Xu and Pfingst, 2003; Kong and Zeng, 2006). Since HiRes with Fidelity 120 (HiRes 120) sound processing captures and sends more spectral information to the cochlea, this study evaluated the potential benefit of HiRes 120 for improving tone-language perception in prelinguistically deaf children who are native speakers of Mandarin Chinese. The hypothesis was that HiRes 120 represents the pitch information and fine structure necessary for distinguishing the tonal contrasts required for understanding words in Mandarin.

Twenty children ages 4 to 17 years participated in the study. Performance was compared between standard HiRes and HiRes 120 sound processing for words that differed in tonal contrast in a two-alternative picture-pointing format. All children used HiRes and HiRes 120 on the body-worn Platinum Sound Processor (PSP). First, they were tested with standard HiRes. Subsequently, they were programmed with HiRes 120 and reevaluated after three months of HiRes 120 use. In addition, at the end of the experiment, the parents of 18 children completed a

questionnaire that evaluated the preference of speech processing strategy and their children's hearing and production abilities when using HiRes 120. Preference for HiRes 120 (versus standard HiRes) was rated on a scale from 0 (no preference) to 10 (strong preference). Evaluation of children's perception and production abilities were rated on a five-point scale (1 = strongly disagree, 5 = strongly agree).

The results showed a range of performance on the tonal contrast test for both HiRes and HiRes 120. Although the mean scores were similar (HiRes mean = 74.3%; HiRes 120 mean = 75.2%), individual scores showed that some subjects derived more benefit from HiRes 120, whereas others performed better with standard HiRes. Figure 1 shows the results for each subject at baseline with HiRes and after using HiRes 120 for three months. Subjects are rank-ordered from lowest to highest performer with standard HiRes. Five children demonstrated higher scores with HiRes 120—with improvements ranging from 9 to 22 percent. In contrast, three subjects performed better with standard HiRes. Twelve children showed equivalent performance for the two sound processing strategies. Notably, six of those 12 subjects scored 90% or higher with standard HiRes, thereby precluding the use of the tonal contrast test for assessing any improvement with HiRes 120. Although 5 of the 20 subjects scored around chance (50%) with their best strategy, 15 children achieved relatively high levels of performance with HiRes or HiRes 120. This finding suggests that some children may rely more on temporal fine structure cues, whereas others use predominantly spectral cues for perception of tonal contrasts.

Figure 2 summarizes the preference results. The parents of 15 of the 18 children (83%) preferred HiRes 120 over standard HiRes, whereas parents of three children indicated no preference. Strength of preference ratings averaged 7.3, with the parents of six children rating their preference as a 10 (strongly preferring HiRes 120).

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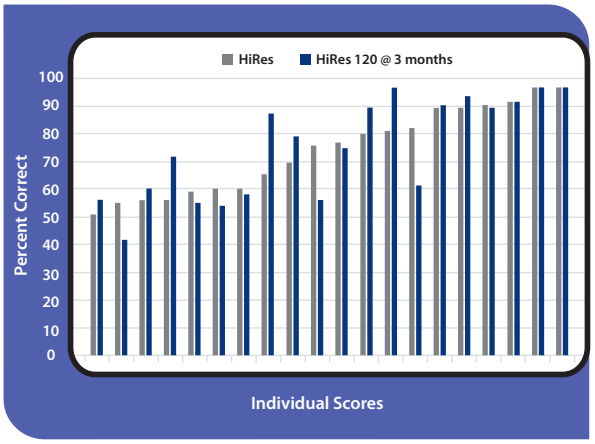

Figure 1. Individual baseline HiRes and three-month HiRes 120 scores on a Mandarin tonal contrast test. Score pairs are rank ordered by baseline HiRes results (chance = 50% correct).

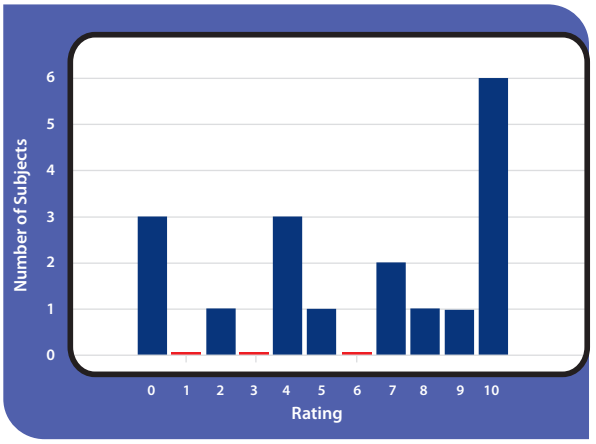

Figure 2. Distribution of strength of preference ratings. Ratings range from 0 (no preference) to 10 (strong preference HiRes 120). Parents of 15 children preferred HiRes 120 whereas parents of three children expressed no preference.

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Table 1. Percent of parents who agreed or strongly agreed with statements regarding HiRes 120 benefits.[†]

Statement of Perceived Benefit with HiRes 120	Percent Responding "Agree" or "Strongly Agree"
My child understands speech better—especially in the presence of background noise.	73%
My child's speech is easier to understand.	87%
My child's speech sounds more natural.	53%
My child alerts to more sounds in the environment.	67%
My child shows more interest in music.	87%
My child sings more.	80%

[†] **Responses are summarized for parents who preferred HiRes 120 (n = 15).**

Table 1 summarizes the questionnaire ratings for the parents who preferred HiRes 120 (n = 15). These results indicate that the majority of parents "agree" or "strongly agree" that HiRes 120 provided improved speech understanding, speech production, and music benefits.

In summary, the results of the present study are encouraging and indicate that the temporal and spectral information delivered by HiResolution sound processing may underlie an improved ability to hear tonal contrasts in some of the Mandarin-speaking children. Parental observations indicate strongly that their children's hearing, speaking, and music listening has improved with HiRes 120. All 20 children continue to use HiRes 120 and will be reevaluated on the tonal contrast test after six months of HiRes 120 experience. In addition, analyses of the children's tone production at baseline with HiRes and after six months with HiRes 120 will be compared in a future report.

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