



Music Perception and Enjoyment with the Harmony® HiResolution® Bionic Ear

HiRes Fidelity 120® Uses Current Steering to Deliver up to 120 Spectral Bands for Increased Potential to Improve Music Appreciation in Harmony HiResolution Bionic Ear Users

Music Perception

Today’s cochlear implant users typically can understand speech remarkably well in quiet. Speech information is conveyed using redundant temporal and spectral cues. In ideal conditions, speech understanding may be accomplished with limited spectral resolution (Shannon et al. 2004). On the other hand, the ability to understand speech in noise and to enjoy music remains poor (Mirza et al. 2003, McDermott 2004). This outcome is not surprising, given the limited spectral resolution delivered by previous generation implant technology. Music perception requires as many as 100 channels of spectral (frequency) resolution even in subjects with normal hearing (Shannon 2005). With the introduction of the HiRes Fidelity 120® (HiRes 120) sound-processing option, Harmony recipients now have access to greater spectral resolution and the potential to improve their music appreciation and perception.*

HiRes 120 is intended to allow implant users to take advantage of their residual place-pitch perception capabilities by delivering spectral information in higher resolution compared to conventional processing. HiRes 120 uses current steering to deliver up to 120 spectral bands. Through simultaneous delivery of current to pairs of adjacent electrodes, the locus of stimulation can be steered to sites between the electrode contacts by varying the proportion of current delivered to each electrode of a pair. There are eight spectral bands implemented for each pair. When all 16 electrodes are enabled, 120 total spectral bands are created (15 pairs times eight spectral bands). The increased spectral resolution, in combination with the fine temporal resolution already implemented in HiRes 120, may lead to better speech perception in noise and improved music appreciation.

Study Design and Subjects

Clinical trial results showed that HiRes 120 increased the frequency, pleasantness, and enjoyment of listening to music when compared to standard HiRes® sound processing (Advanced Bionics 2007, Oleson et al. 2008). Therefore, a multicenter study was designed to further explore music benefits that adults derive from HiRes 120. The study explores the relationships among a range of music perception abilities, ratings of everyday music listening and enjoyment, speech recognition, and demographic variables.

Subjects to date are 43 adults implanted with an Advanced Bionics’ implant (CII Bionic Ear®/HiRes 90K®) who use the Harmony processor programmed with HiRes 120. Demographic information is in Table 1 on page 2.

CONTENTS

Music Perception	1
Study Design and Subjects	1
Everyday Music Listening	2
Appreciation of Music by Cochlear Implantees	2
Music Scores and Speech Perception	3
Summary and Implications	3
Participating Study Sites.....	4
References.....	4

*HiRes Fidelity 120 is not approved for pediatric patients in the United States.

Table 1. Demographics of study participants.

Variable	Mean	Range
Age at Implant	51 years	19 to 83 years
Duration of Severe-to-Profound Hearing Loss	12 years	1 to 48 years
Duration of Implant Use	5 years	1 to 23 years
Duration of HiRes 120 Use	11 months	3 to 23 months

Everyday Music Listening

A questionnaire adapted from Mirza et al. (2003) was used to evaluate everyday music listening experience. Figure 1 shows the individual ratings for music enjoyment with HiRes 120 (0 = not at all, 10 = very much). Of the 43 adults, 36 report enjoying music to some extent (rating of 3 or higher). Mean ratings of music enjoyment and frequency of music listening (0 = never, 10 = very often) are shown in Figure 2 along with the corresponding mean results reported by Mirza and colleagues for users of other technologies. The comparisons show that HiRes 120 users listen to and enjoy music more than users of older devices. In addition, comparison of the HiRes 120 results to demographic data indicate that music enjoyment is greater for individuals implanted at a younger age, and for individuals who have used their devices longer.

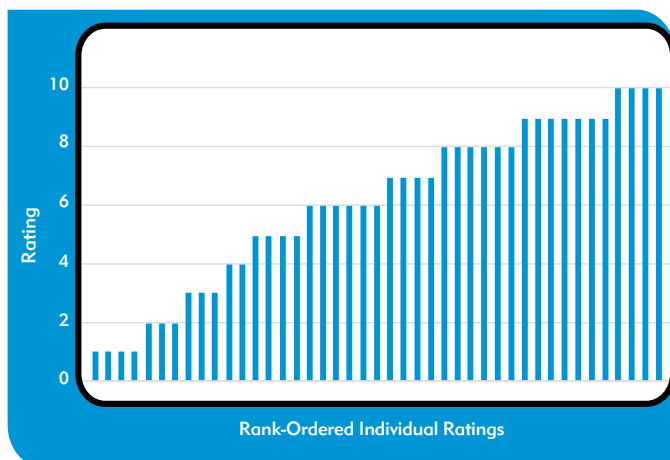


Figure 1. Individual ratings for music enjoyment (0 = not at all, 10 = very much). Eighty-four percent of adults (36 of 43) enjoy music to some extent with HiRes 120 (rating of 3 or higher).

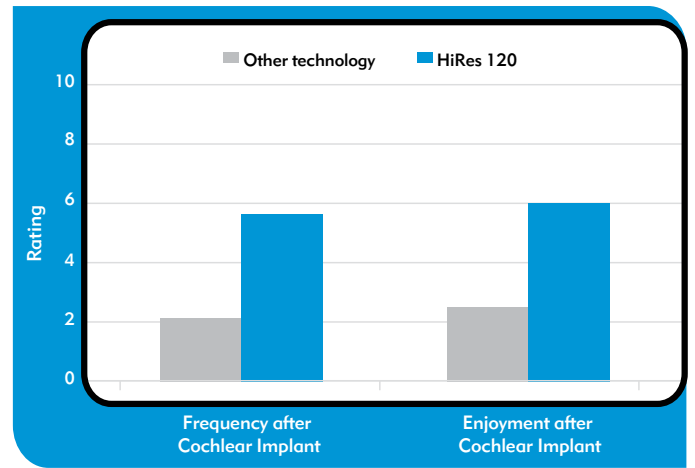


Figure 2. Mean ratings for frequency of listening to music and enjoyment of music for users of other technology (n =35) and for users of HiRes 120 (n = 43).

Appreciation of Music in Cochlear Implantees (AMICI)

The AMICI test battery developed by Spitzer et al. (2008) also was administered. The AMICI stimuli consist of short musical pieces selected from commercial recordings. The Instrument Identification subtest requires subjects to identify a target instrument or male/female vocalist from a closed set of 10 options. The Musical Styles subtest requires listeners to identify the genre of a musical selection from a closed set (rock/pop, classical, country/western, jazz, Latin). The Musical Pieces subtest consists of selections (instruments only or instruments with lyrics) that are considered to be part of the American cultural mainstream. In an open-set task, the target piece can be identified by naming the song, composer, or performer; naming an associated movie or TV show; or singing/humming the melody.

Results for the Instrument Identification test show a mean score of 71% with 25 of 43 subjects scoring 70% or better (Figure 3). On the Musical Styles test, the mean score was 69% and all subjects scored above chance (Figure 4). On the difficult open-set Musical Pieces test, the mean score was 45% and 11 subjects scored 70% or greater (Figure 5). These mean scores compare favorably to results reported by Spitzer and colleagues (2008). On all three subtests, the mean scores of the HiRes 120 listeners were higher than the mean scores for 11 implanted adults tested during the development of the AMICI (Figure 6).

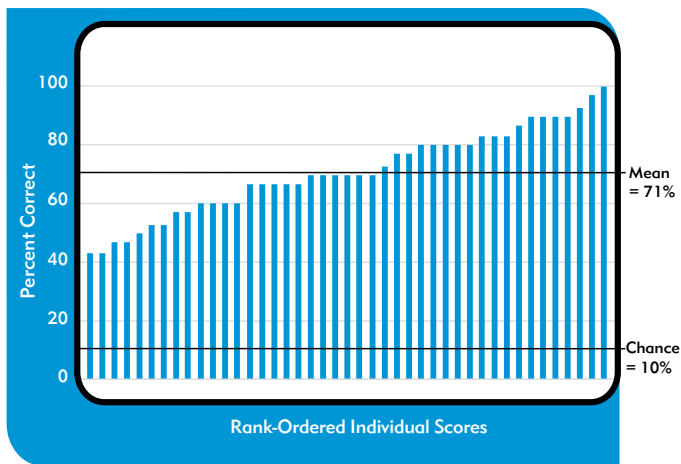


Figure 3. Individual scores for the AMICI Instrument Identification test. Fifty eight percent of subjects (25 of 43) scored 70% or better.

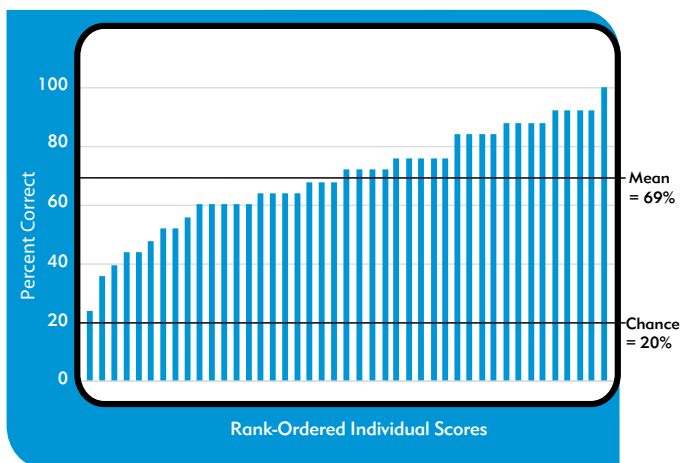


Figure 4. Individual scores for the AMICI Musical Styles test. All subjects scored above chance.

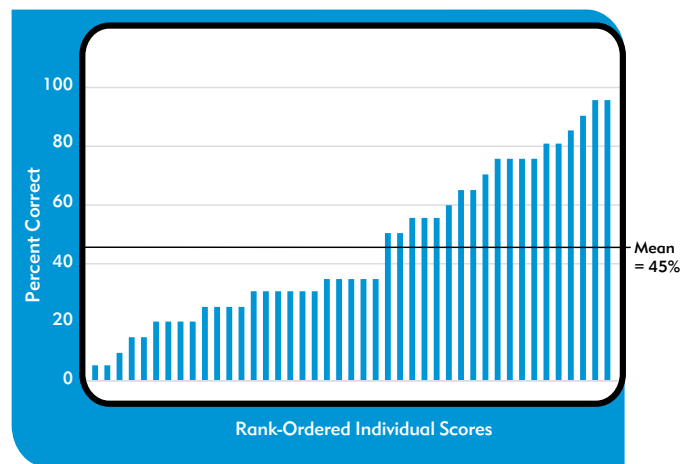


Figure 5. Individual scores for the AMICI Musical Pieces test. Eleven subjects scored 70% or better.

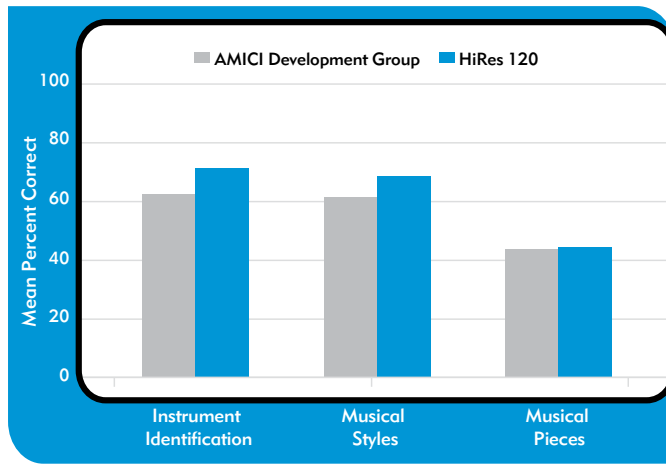


Figure 6. Mean scores for the AMICI Instrument Identification, Musical Styles, and Musical Pieces subtests for 11 implant recipients tested during development of the AMICI (5 HiRes users, 3 ACE users, 2 CIS users, 1 SPEAK user) (Spitzer et al. 2008) and 43 HiRes 120 users.

Notably, AMICI scores were not correlated with ratings of music enjoyment. Scores on the AMICI subtests also were unrelated to any of the demographic variables.

Music Scores and Speech Perception

Speech perception was evaluated using CNC words (Petersen and Lehiste 1962) and the BKB-SIN test (Etymotic Research 2005). Scores on these two tests showed modest correlations with scores on the AMICI subtests, with the exception of Musical Styles and CNC words (see Table 2). That is, individuals who had high scores on the speech tests tended to perform better on the music tests, and vice versa.

Table 2. Correlations between speech and music results.

	CNC Words	BKB-SIN
AMICI Instrument Identification	$r = 0.42, p < .01$	$r = -0.53, p < .001$
AMICI Musical Styles	$r = 0.38, p = .014$	$r = -0.55, p < .001$
AMICI Musical Pieces	$r = 0.46, p < .01$	$r = -0.79, p < .001$

Summary and Implications

Music perception and enjoyment are greater in users of HiRes 120 than in users of other technologies. The fact that music enjoyment is higher in individuals who are implanted younger and who have used their devices longer suggests that music listening skills and appreciation may improve as users gain more experience with their Harmony Sound Processor. Notably, scores on tests of

music perception are not related significantly to users' self report of music enjoyment. That is, even cochlear implant recipients who do not score well on clinical music tests may derive considerable everyday pleasure from listening to music.

With HiRes 120, Harmony recipients have the opportunity to hear and to enjoy music better than ever before. The results from this ongoing study indicate that HiRes 120 is delivering the acoustic information required to be successful in hearing both speech **and** music. Clinicians who work with implant recipients might consider incorporating tests of music perception into their post-implant test batteries to explore the additional music benefit offered by HiRes 120.

Participating Study Sites

Advanced Bionics, Sylmar, CA
Cleveland Clinic Foundation, Cleveland, OH
Columbia University Medical Center, New York, NY
House Ear Clinic, Los Angeles, CA
Houston Ear Research Foundation, Houston, TX
Mayo Clinic, Rochester, Minnesota
Medical University of South Carolina, Charleston, SC
New York University Medical Center, New York, NY
Ottawa Hospital (Civic Campus), Ottawa, ON

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