Music recognition by children with cochlear implants

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Abstract. Poor pitch resolution interferes with cochlear implant users' ability to recognize music from pitch cues alone. We examined the possibility that prelingually deaf implant users could identify familiar hit songs from commercial recordings presented with or without words. Young implant users 8–18 years of age and age-matched hearing controls attempted to identify original and altered recordings of familiar hit songs. Cochlear implant users succeeded in identifying the songs, with or without words, from a closed set, but they were less accurate than the matched sample of hearing listeners. Unlike their peers with normal hearing, most cochlear implant users were unable to identify the songs from simple piano renditions of the main melody or from bass-and-drum renditions. Despite their music processing limitations, these young implantees provided favorable appraisals of the music. © 2004 Elsevier B.V. All rights reserved.

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1. Introduction

Although music and speech consist of sound patterns that unfold over time, they differ dramatically in their auditory processing demands. Whereas reasonable speech perception is possible with intact temporal cues but degraded spectral cues, music perception depends critically on intact spectral cues [1]. Adult cochlear implant (CI) users are roughly comparable to normally hearing (NH) individuals in the perception of rhythm [2], but their pitch resolution, estimated at approximately four semitones [3], is orders of magnitude greater than that of listeners with normal hearing. It is not surprising, then, that CI adults have difficulty identifying music on the basis of pitch cues alone [3] and that they derive limited pleasure from music.

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Relatively little information is available on the music perception skills of prelingually deaf children who use cochlear implants. According to Stordahl [4], CI children have difficulty recognizing familiar songs when no words are provided and they give negative appraisals of most music. The purpose of the present investigation was to determine whether CI children and adolescents were capable of identifying familiar hit songs on the basis of unique acoustic cues from the commercial recordings.

2. Materials and methods

The final sample included 10 prelingually deaf participants 8–18 years of age (M=12.4, S.D.=4.1) who had been using an implant consistently for at least 1 year (M=5.7 years, S.D.=4.2). These children and adolescents were successful implant users, as reflected in good speech perception and production skills. Moreover, all were familiar with at least three of the hit recordings in our stimulus set. An age-matched sample of children and adolescents with normal hearing was selected on the basis of their familiarity with the musical materials. Each participant achieved performance levels of 0.75 or greater (out of a perfect score of 1) on the original recordings, which confirmed their familiarity with the musical materials in the test set. A few other CI and NH participants were excluded on the basis of their failure to meet this familiarity criterion.

Testing was conducted in a double-wall sound-attenuating booth (IAC). Stimuli were delivered by means of an iMac computer and two loudspeakers (Bose Lifestyle Cube) at approximately 70 dB (A scale). Each listener was tested on 3 to 5 songs from a set of 14 hit songs that were reportedly familiar to many CI as well as hearing youths, as determined by questionnaires or interviews involving potential participants or their parents. There were four versions of each song: (1) the original commercial recording, (2) an identical or nearly identical version except for the absence of vocals, (3) a synthesized piano rendition of the main melodic theme and (4) a synthesized rendition that reproduced the bass line and drum accompaniment of the original recording. The song versions were presented in blocks, each block corresponding to one of the four versions, which were presented in fixed order (1, 2, 3 and 4). Within each block, each song was presented twice and all songs were presented in random order with the constraint that no song could appear twice in succession. The participants first indicated their recognition of the song by depressing a key on the computer keyboard. Then, they identified the song by selecting the image of one of the pop singers or groups that appeared on screen along with the song title. CI listeners performed two additional tasks. They indicated how much they liked each rendition on a five-point Likert scale (1=very much, 3=indifferent, 5=not at all). In addition, they completed the Picture Locations subtest of the Children's Memory Scale [5], which provides an estimate of visual-spatial working memory.

3. Results

Because participants had different numbers of song alternatives (3–5), raw scores were transformed to compensate for different probabilities of achieving a correct response by
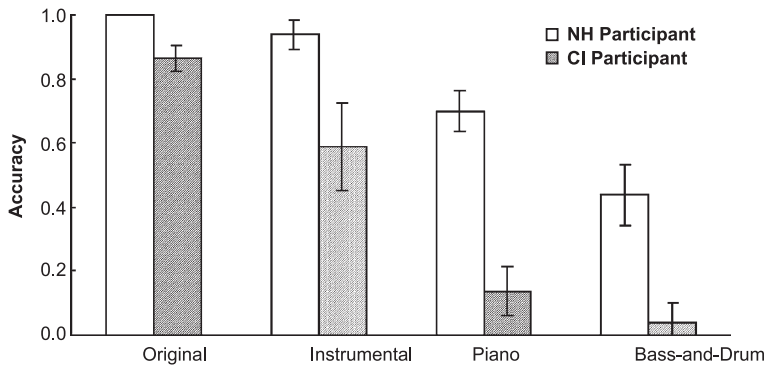
Fig. 1. Accuracy scores of cochlear implant participants and age-matched hearing controls on the four song renditions.

chance. On the transformed scale, scores of 1.0 indicated perfect performance and scores of 0 indicated chance levels. Performance of CI and NH listeners on the four renditions is shown in Fig. 1. A two-way repeated-measures analysis of variance (2 groups×4 renditions) revealed a significant main effect of group, with NH participants (M=0.81, S.D.=0.08) performing more accurately overall than CI participants (M=0.41, S.D.=0.13), $F(1,9)$=47.561, p<0.0001. The main effect of rendition was also significant, $F(3,27)$=39.131, p<0.0001. Of particular interest was the significant interaction between group and rendition, $F(3,27)$=3.828, p=0.021, which confirmed different patterns of performance across renditions for CI and NH listeners. As can be seen in Fig. 1, CI listeners performed relatively well on the original and instrumental renditions, even though their performance was less accurate than that of NH listeners. Unlike NH listeners, however, CI listeners were at chance levels on the melody and bass-and-drum renditions.

CI listeners' performance on the challenging piano renditions was correlated significantly with working memory (scaled score on the Picture Locations subtest of the Children's Memory Scale), $r(8)$=0.737, p=0.015; age, $r(8)$=0.710, p=0.021; and length of implant use, $r(8)$=0.678, p=0.031. Analyses of partial correlations revealed that age and working memory retained reliable associations with performance. By contrast, length of implant use did not have a reliable partial correlation with performance after age or working memory were held constant.

CI listeners' appraisals of the music were significantly more favorable than the neutral midpoint of the Likert scale for the original renditions, $t(9)$=6.418, p<0.0001, instrumental renditions, $t(9)$=4.875, p=0.001, and bass-and-drum renditions (M=1.89), $t(9)$=3.170, p=0.011. For the piano renditions, the difference between appraisals and the neutral midpoint approached conventional significance levels, $t(9)$=2.065, p=0.069.

4. Discussion

CI users successfully identified familiar songs from multiple cues, vocal or instrumental, that were available in the original recordings. Unlike NH listeners, they

were unable to identify simple piano renditions of the melody even though those renditions preserved the original timing cues. CI listeners' difficulty with these piano renditions may stem primarily from their poor pitch resolution, which would reduce the distinctiveness of each melody, and from the absence of familiar vocal or instrumental features from the original recordings. The contribution of working memory and age to CI listeners' recognition of the piano renditions indicates the importance of general cognitive factors in music perception on the basis of fragmentary pitch cues. In short, CI listeners' representations of music seem to differ drastically from those of hearing individuals, with relative pitch cues playing a minor role and surface features of the music playing a major role. Perhaps the most striking lesson from CI participants in the present study is the positive value that they ascribed to the limited musical information that was accessible to them.

Acknowledgements

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