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Music Recognition by Japanese Children with Cochlear Implants

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Abstract Congenitally deaf Japanese children with cochlear implants were tested on their recognition of theme songs from television programs that they watched regularly. The children, who were 4-9 years of age, attempted to identify each song from a closed set of alternatives. Their song identification ability was examined in the context of the original commercial recordings (vocal plus instrumental), the original versions without the words (i.e., karaoke versions), and flute versions of the melody. The children succeeded in identifying the music only from the original versions, and their performance was related to their music listening habits. Children gave favorable appraisals of the music even when they were unable to recognize it. Further research is needed to find means of enhancing cochlear implants users' perception and appreciation of music. *J Physiol Anthropol Appl Human Sci 24(1): 29–32, 2005* http://www.jstage.jst.go.jp/browse/jpa

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Introduction

A cochlear implant is an auditory prosthesis with a microphone for receiving sounds in the environment, an external processor for converting those sounds into electrical signals, and a system for transmitting the signals to surgically implanted electrodes in the inner ear (Loizou, 1998). The device makes it possible to bypass a damaged hearing system and deliver electrical stimulation to the auditory nerve. Although the prosthesis provides degraded spectral information, relatively preserved temporal information enables many postlingually deaf adults to achieve good speech perception skills within several months of implantation. Congenitally deaf children have the additional challenge of acquiring their native language by electrical or "artificial" hearing alone. With appropriate support, these children often achieve good speech and language skills (Svirsky et al., 2000), although their initial progress is considerably slower than that of postlingually deaf adults. For congenitally or prelingually deaf children, early age of implantation is associated with higher levels of ultimate achievement (Miyamoto et al., 1999).

Because the external processor is engineered to optimize speech perception, it is not surprising that it functions poorly for music perception. In contrast to speech recognition, which is possible with coarse spectral cues and precise temporal cues (Shannon et al., 1995), music recognition depends primarily on precise pitch cues and only secondarily on temporal cues (Zatorre et al., 2002). For example, listeners can usually identify familiar melodies on the basis of pitch relations but not on the basis of temporal relations (Hébert and Peretz, 1997).

Unfortunately, there is relatively little understanding of the music perception skills and limitations of cochlear implant users. The available research indicates, however, that adult implant users are roughly comparable to hearing listeners in rhythm perception (Gfeller et al., 1998), but not in melody perception. One account estimates that implant users' pitch resolution is about four semitones (Fujita and Ito, 1999), which would preclude melody identification in most cases. Indeed, implanted adults and children seem unable to identify melodies or songs from pitch cues alone (Fujita and Ito, 1999; Gfeller et al., 2000; Stordahl, 2002). It is not surprising, then, that many adult implant users avoid music, even if it was a highly valued activity prior to their hearing loss (Gfeller et al., 2002).

Child implant users differ from adults in important respects. Having never experienced music as hearing persons do, they would not mourn its loss. On the one hand, they may be unable to hear music as a coherent pattern from the fragmentary pitch cues that are available. On the other hand, greater cortical plasticity (Bates et al., 2001) may enable them to achieve levels of musical enjoyment or skill that are impossible for adult implant users.

To date, there has been limited focus on the music listening experiences of child implant users. Recently, Vongpaisal et al. (2004a) assessed the music recognition skills of 10 cochlear implant users who were 8–18 years of age, along with age-matched hearing listeners. Instead of testing them on familiar

folk or traditional songs (e.g., "Happy Birthday"), they used popular recordings that the participants listened to regularly. After hearing an excerpt from a song, participants attempted to identify it from a set of alternatives. There were four versions of the task, including original commercial recordings (vocal plus instrumental), original versions with words omitted (i.e., same instruments), piano versions of the melody, and bass-and-drum accompaniment. Cochlear implant users performed more poorly than their hearing peers, but they identified the original and instrumental (karaoke) versions at well above chance levels. They were unable, however, to identify the melody or bass-and-drum versions. By contrast, hearing listeners performed above chance levels on all versions. Of particular interest was implant users' favorable ratings of the music and their participation in the task. Despite their limited melody recognition skills, the deaf children and teens enjoyed the music, and they enjoyed participating in the task.

Younger implant users and age-matched hearing children were also tested on their recognition of theme songs from their favorite television programs (Vongpaisal et al., 2004b). These children had been exposed to the music incidentally while watching TV rather than deliberately listening to it. They were tested on different versions of the task, which involved the original music, instrumental versions, and melody versions. Hearing children successfully identified all versions, but implanted children succeeded only on the original versions with words. It might seem that the presence of words would eliminate any problems with identification, but implant users commonly have difficulty decoding the words of unfamiliar songs.

The purpose of the present study was to replicate and extend the findings of Vongpaisal et al. (2004b) with congenitally deaf children from Japan and theme music from Japanese TV programs. Replication is important because the Vongpaisal et al. (2004b) study is the first of its kind. Moreover, a Japanese sample is of particular interest because music education in the early years is more widespread in Japan than in many other countries (Miyoshi, 2000). One consequence of that situation is the considerably greater incidence of absolute pitch in Japan than in North America (Ward, 1999). We also sought to determine whether children's informal music-listening and music-making activities influenced their recognition of musical materials heard incidentally while watching their favorite television programs. Answers to questions such as these might guide future rehabilitation efforts with this population.

The children were tested on original versions, instrumental (karaoke) versions, and synthesized flute versions of the main melody. Because hearing Japanese children remember more detail from incidental music exposure than hearing Canadian children do (Nakata et al., 2004), it was possible that deaf Japanese children would identify TV theme music more readily than their deaf Canadian peers.

Method

Participants

The participants were 13 congenitally deaf Japanese children 4–9 years of age (M=6.7, SD=1.4) who had used a cochlear implant for at least one year (M=2.9, SD=1.1) and watched the target TV programs regularly. All children used their implant consistently and were observed conversing successfully with the experimenter or their parents. Because young hearing children in North America readily recognized all versions of the music, the presumption was that Japanese hearing children would do likewise. Accordingly, no hearing children were included in the present study.

Apparatus and stimuli

Fourteen theme songs from popular TV programs (see Table 1) were chosen on the basis of: 1) popularity among children 4–10 years of age, 2) commercial availability of vocal/instrumental (original) and instrumental (karaoke) recordings, and 3) sung rather than spoken (rap) lyrics. A synthesized flute version of the main melody (i.e., the sung portion) of each song preserved the original timing. The duration of the excerpts was 55–65 seconds, beginning with the initial portion of the song. Song versions were presented in blocks and in fixed order: original, instrumental, and melody versions. Each song was presented twice within each test block, with the restriction that no song occurred twice in a row. Testing, which occurred in a double-wall sound-attenuating booth, was conducted by means of a customized, interactive program on an Apple iBook computer. Audio stimuli were amplified and presented over a loudspeaker, with the intensity adjusted to the comfort level of each child. Images of the main characters and titles of the TV programs were displayed on the computer monitor.

Procedure

Children were tested individually. On the basis of preliminary discussions with children and parents, we selected 3–5 TV programs that each child viewed regularly. Children were instructed to listen carefully to each excerpt and to

Table 1 TV programs used for musical selections

Anpanman
Doraemon
Tottoko Ham-Taro
Hoshi no Kerby
Nintama Rantaro
Ojaru maru
Pocket monster
Inuyasya
Atashinchi
Mujinwakusei Survive
Meitantei Conan
Casmin
Ashita no Naja
Sonic X

identify the TV program or song by clicking on the appropriate image or title on the monitor. They were told to guess if they were unsure. The experimenter presented a musical excerpt when children were attentive, stopping the music when they indicated their readiness to respond. After children selected one of the programs indicated on the monitor, they rated how much they liked each musical sample on a 5-point display (also on the monitor) consisting of 5 ice cream cones of different sizes accompanied by the words "not at all" for the smallest cone (rating of 1) and "very much" for the largest (rating of 5). After completing all trials of the original versions, children proceeded immediately to the instrumental versions and then to the melody versions. Parents subsequently mailed in a questionnaire about the child's music-listening habits and music-making activities.

Results

To adjust for variable song-identification alternatives (3, 4, or 5) across children, correct responses were converted to accuracy scores by the following formula:

$$\text{Accuracy score} = (P(O) - P(E))/(1 - P(E)),$$

where P(O) was the observed proportion of correct identification in each block and P(E) was the expected proportion of correct identification by chance. Scores of 0 denote performance at chance levels. Positive scores indicate performance above chance (perfect score=1), and negative scores indicate performance below chance levels.

Performance exceeded chance levels for the original song versions (M=.43, SD=.41), $t(11)$=3.58, p<.005, but not for the instrumental versions (M=−.02, SD=.12), $t(10)$=−.61, p>.50, or melody versions (M=−.08, SD=.20), $t(9)$=−1.32, p>.20. A one-way analysis of variance on mean accuracy scores revealed a significant effect of song version, $F(2,18)$=16.06, p<.001, and post-hoc t-tests revealed better performance on the original versions than on the other versions, ps>.005.

Children's appraisals of the music were generally favorable, significantly exceeding the neutral midpoint (indifferent) of the 5-point scale for instrumental versions (M=3.50, SD=.55), $t(10)$=3.00, p<.05 (one-tailed), melody versions (M=3.67, SD=.75), $t(9)$=2.79, p<.05 (one-tailed), and original versions (M=3.47, SD=.80), $t(11)$=2.03, p<.05 (one-tailed). Correlations between appraisals and identification accuracy were not significant for the original versions, $r(12)$=.45, instrumental versions, $r(11)$=.23, or melody versions, $r(10)$=.21, ps>.05.

Of the 10 children for whom questionnaires were available, 9 sang at home, but only 4 listened to music as a distinct activity. Most of the children who sang regularly (7 of 9) reportedly danced and/or smiled while they sang. Regular, deliberate listening to music predicted identification accuracy on the original versions, with children who initiated music listening activities performing better (M=.75 and SD=.29) than those who did not do so (M=.29 and SD=.43), $t(8)$=1.84, p=.05 (one-tailed). The relation between how often children sang and their identification of original renditions was not significant, $r(9)$=.13, p>.05.

Discussion

Congenitally deaf Japanese children with cochlear implants were evaluated on their identification of music that accompanied the television programs that they watched regularly. The children successfully identified the music only for original versions that featured words and instrumental accompaniment. When the words were absent or when a solo flute played the melody, they were unable to recognize the music. These findings are consistent with Canadian children's failure to identify instrumental versions of the theme songs of familiar television programs (Vongpaisal et al., 2004b). They are also consistent with implanted children's failure to recognize "familiar" music from pitch cues alone (Stordahl, 2002). Although deliberate listening to other music predicted children's identification of the television theme music, it is unclear whether such listening experience was a cause or consequence of superior music perception. This question can be addressed in further research.

Just as Canadian children and teens with cochlear implants provided positive appraisals of familiar popular songs (Vongpaisal et al., 2004a), Japanese children with implants rated the television theme songs favorably. Their ratings of the musical samples were unrelated to their ability to identify them, but this is undoubtedly due to the small sample size and lack of statistical power. Parental reports indicated that most children derived considerable pleasure from music, which corroborated children's favorable appraisals of the musical materials in the present study.

Many questions remain unanswered. Perhaps the most important challenge for future research is to find ways of making music more accessible and more rewarding for children and adults with impaired hearing, whether they use cochlear implants or hearing aids.

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