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Song Recognition and Appraisal: A Comparison of Children Who Use Cochlear Implants and Normally Hearing Children

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The purpose of this study was to compare song recognition and song appraisal of children (ages 8–15) who use cochlear implants and normally hearing children. The Iowa Music Perception and Appraisal Battery—Children's Version was developed to measure these differences. Fifteen children who use cochlear implants and 32 normally hearing children participated in this testing battery. The battery includes a Song Recognition Test, a Song Appraisal Test, and a Musical Background Questionnaire. The cochlear implant recipients were significantly less accurate ($p < .0001$) than normally hearing children on the Song Recognition Test. Cochlear implant recipients also demonstrated greater dislike than normally hearing children for all items on the Song Appraisal Test. Despite these differences, cochlear implant recipients were quite similar to normally hearing children in terms of self-reported informal musical involvement and music listening habits.

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Introduction

The cochlear implant is an assistive hearing device designed to improve speech perception for persons who have bilateral profound hearing losses and who receive little, if any, benefit from hearing aids. There are several differences between a hearing aid and a cochlear implant. Hearing aids tend to be more effective in cases of conductive hearing losses, which are caused by disease, obstruction, or injury to the outer or middle ear. In short, hearing aids amplify sound.

Cochlear implants are used in cases of severe to profound sensorineural hearing losses. A sensorineural hearing loss results from damage or injury to the inner ear structures. In particular, the hair cells of the inner ear may be damaged or missing, which causes a breakdown in the transmission of sound waves from mechanical to electrical energy (Gfeller, 1998). Although some individuals with sensorineural hearing losses can benefit from hearing aids (Tyler & Fryauf-Bertschy, 1992), mere amplification may not always be helpful. Those persons with profound losses, particularly in high frequencies, may receive greater benefit from a cochlear implant (Gfeller, 1998).

While a hearing aid amplifies the sound, a cochlear implant is an electronic device that provides artificial electrical stimulation to the auditory nerve (Gfeller, 1998). The cochlear implant has several components. The microphone picks up sound energy and converts it into an electrical signal. This signal is sent to an external processor that filters the sound wave, transmitting only those parts of the sound signal considered salient to speech perception. This processed signal is transmitted to the internal electrode array located in the cochlea, where electrical stimulation of the auditory nerve takes place. It is important to remember that a cochlear implant delivers only part of the total sound signal and as a result does not replicate normal hearing (Gfeller, 1998). While the processing and transmission of selective aspects of the sound wave have proven quite successful in speech perception, there are serious limitations with regard to the representation of musical sounds. In particular, cochlear implant recipients do not receive a normal representation of either pitch or timbre, which are both important structural features in music (Gfeller et al., manuscript submitted for publication).

To date, a modest body of research has been accumulated regarding music perception of implant recipients. Within that small data base, even less research exists regarding the musical perception and preference of children who use cochlear implants. This topic is of practical interest with regard to implant benefit because, in our society, music is both an art form and a social activity. Further, a greater understanding of musical perception by cochlear implant recipients may address such issues as user satisfaction with daily functioning. Prior research indicates that children with cochlear implants are involved in a variety of social and educational activities that require audition, including music (Gfeller, Witt, Spencer, Stordahl, & Tomblin, 1999). Therefore, the aim of the present research was to gain a greater understanding of the song recognition abilities, music preferences, and music experiences of children who use cochlear implants[1].

Review of Literature

An understanding of the music perception of children who use cochlear implants can be enhanced by considering several related topics. Those topics include music perception and preferences of adults who use cochlear implants; consideration of tests used to measure music perception and appreciation; research comparing music perception of children who use conventional hearing aids with those who use cochlear implants; and research comparing music perception and preference of children with normal hearing and children with hearing losses (including those who use conventional hearing aids as well as cochlear implants).

Music perception of adults who use cochlear implants. To date, most tests of music perception and appreciation have been with postlingually deafened adults, that is, persons who grew up with relatively normal hearing and who therefore have a normal mental representation of musical structures such as pitch, rhythm, harmony, and timbre. Tests with adult cochlear implant recipients reveal several basic trends. Implant recipients perform similarly to normally

[1] The author wishes to acknowledge differing viewpoints (particularly among some members of the Deaf Community) regarding cochlear implantation of children. It is an interesting issue worthy of examination and discussion; however, that topic is beyond the scope of this paper. This paper instead presents objective measurements as well as results concerning the musical perception, appraisal, and enjoyment of children who already have cochlear implants.

hearing adults on rhythmic perception, but less accurately on tasks that require perception of pitch, timbre recognition, or appraisal (that is, liking) of sound quality. For example, Gfeller and Lansing (1991) investigated adult cochlear implant recipients' perception of melodic and rhythmic patterns, as well as quality ratings for different musical instruments (n = 18). The measurement tools included Gordon's Primary Measures of Music Audiation (PMMA) and the Musical Instrument Quality Rating Scale. The PMMA is a test of musical aptitude designed for children. It is a standardized test of musical perception containing two subtests: Tonal and Rhythm. The test assesses the ability to hear differences in short tonal and rhythmic patterns, and to determine if each item pair is the same or different. In the Musical Instrument Quality Rating Scale, subjects select adjectives to describe the timbres of a variety of musical instruments. They are also asked to identify the name of the melody and the name of the instrument. PMMA results revealed that subjects performed similarly to normally hearing adults on the Rhythm subtest, but were significantly less accurate than normally hearing adults on the Tonal subtest. The Musical Instrument Quality Rating Scale results revealed that subjects were able to recognize the title of the melody for only 5% of the total trials and the correct instrument name for only 13.5% of the total trials.

One of the research issues regarding this population has been the selection of suitable measures—measures that can distinguish between normally hearing adults and implant recipients, as well as discriminate among those implant recipients who achieve minimal versus considerable benefit from the implant. Gfeller and Lansing (1992) evaluated the effectiveness of the PMMA as a test of musical perception for postlingually deafened adult cochlear implant recipients. A key finding of this study was that the PMMA may be limited in discriminating among poor and strong implant recipients, particularly on listening tasks that require more than a simple discrimination of same or different. That finding acted as a key incentive for the development of a music perception and appreciation test designed expressly for adult cochlear implants recipients, the Iowa Music Perception and Appraisal Battery (IMPAB).

Subsequent research studies reporting results of subtests within the IMPAB indicate that postlingually deafened adult cochlear implant recipients are significantly poorer than normally hearing adults on a variety of tasks, including simple song recognition, tim-

bre recognition, and appraisal of sound quality (Gfeller, et al., 1998, 2000; manuscript submitted for publication).

Music perception of children with and without hearing losses. Children who have congenitally or prelingually-acquired hearing losses often demonstrate delays in some, though not all, music-based skills. Darrow (1984) and Gfeller (2000) found that children who are deaf or hard of hearing perform at least as effectively as normally hearing children with respect to rhythmic tasks, specifically, beat identification, tempo change, and accent. However, Darrow (1987) administered the PMMA to children with severe or profound hearing losses in primary grades (1–3) and found that their tonal, rhythm, and composite scores were significantly lower than scores representing normally hearing children. In addition, several studies also revealed significantly poorer performance than normally hearing children on tasks requiring perception of intervals, pitch patterns, or harmony, especially in cases of moderate to profound loss (e.g., Darrow, 1987; Ford, 1988; and Gfeller, 2000).

Music perception and enjoyment of children who use cochlear implants. An important distinction between postlingually deafened cochlear implant recipients and children who essentially grew up hearing through a cochlear implant is that postlingually deafened implant recipients have an internal representation of what music sounds like through a normal hearing mechanism. Children with prelingual hearing losses who have heard primarily through cochlear implants have learned how music sounds essentially through a device that provides an abnormal representation of pitch and timbre (Gfeller, 2000).

Because of this difference, Gfeller, et al. (1999) investigated to what extent children who use cochlear implants were involved in informal music activities, in formal music instruction, as well as the general attitude of children with cochlear implants towards music. A questionnaire was developed and disseminated to the parents of children (ages 2–20) who use cochlear implants ($n = 65$). Seventy-three percent of elementary students and 32% of the junior and senior high school students who use cochlear implants participated in music instruction. The most common types of formal musical instruction in which these children participated were: general music class (46%), participation in school musicals (29%), individual or small group music lessons (20%), choir (20%), and band (11%).

Sixty-three percent of children who use cochlear implants listen

to music informally at home or in the community. In terms of informal music involvement, the most common activities were: listening to music informally at home or in the community (63%), dancing to music (55%), watching music videos (42%), attending music programs at school (40%), buying CDs or tapes (34%), participating in family music activities (32%), and attending concerts (32%). In short, a large proportion of children who use cochlear implants are involved in some type of formal or informal musical activity, despite the fact that the implant has been designed primarily for speech perception.

While these questionnaire data provide valuable information regarding musical involvement and enjoyment of children who use cochlear implants, they provide little insight regarding perceptual accuracy. In preliminary studies comparing children using cochlear implants to those using conventional hearing aids, the cochlear implant recipients have shown a wider range of perceptual accuracy than have the hearing aid users; furthermore, the overall mean score for small samples of implant recipients was well above that of hearing aid users for both rhythmic and melodic perception on Gordon's PMMA (Gfeller, 2000). However, these preliminary data leave many unanswered questions regarding music perception of children with prelingual hearing losses who grow up listening to music through a cochlear implant. Therefore, the purpose of this study was to develop a test that would determine song recognition abilities and song appraisal of school aged children (ages 8–15). The test was administered to children who use cochlear implants and to a comparison group of normally hearing children.

The purpose of this research was to answer the following questions. First, how do children who use cochlear implants compare with normally hearing children in terms of song recognition and appraisal (measured via the Song Recognition Test and the Song Appraisal Test)? Second, are there differences between groups in terms of musical involvement, listening habits, and music preferences (measured via the Musical Background Questionnaire)?

Method

Participants

Participants included 15 prelingually deafened cochlear implant recipients (children deafened before the acquisition of language).

TABLE 1
Participant Characteristics

	CI Children	NH Children
N	15	32
Mean age	11.07	11.09
Age range	8–14	8–15
Females : Males	7 : 8	15 : 17

Participants were recruited via the Iowa Cochlear Implant Research Center. Children who were between the ages of 8 and 15 and who were coming to the center as part of annual visits were invited to complete this testing in addition to their regularly scheduled testing. Ages ranged from 8 to 14 years, with a mean age of 11.07 years. There were 7 females and 8 males.

Thirty-two children with normal hearing also completed the testing. Participants were recruited from the community via an advertisement in a newsletter. A hearing screen was administered prior to testing to ensure that each child had normal hearing. In addition, each child was compensated for his/her time and inconvenience. Ages ranged from 8 to 15 years, with a mean age of 11.09 years. There were 15 females and 17 males. Participant characteristics for both children who use cochlear implants and normally hearing children appear in Table 1.

Two postlingually deafened cochlear implants recipients (children deafened after the acquisition of language) also completed the testing. CI 4 is a 12-year-old male. CI 10 is a 13-year-old female. The data for these individuals are reported for the sake of interest; the data were not incorporated into group analyses or comparisons. The reason for this exclusion was that the postlingually deafened cochlear implant recipients have internal representations of music, speech, and other sounds that prelingual cochlear implant recipients do not have. Further, postlingual cochlear implant recipients vary greatly from prelingual cochlear implant recipients in a variety of ways. In addition, two postlingually deafened children were judged as too small a sample to constitute a comparison group in the statistical analyses. Future research may compare song recognition abilities and musical preferences of prelingual versus postlingual cochlear implant recipients.

Measures

Song recognition and appreciation. The IMPAB has been proven to be a reliable and valid measure for adults who use cochlear implants. However, it includes items and listening tasks that are more suitable for individuals with postlingual hearing losses or tasks that are developmentally too difficult for young children. Therefore, a logical next step was to develop a test similar to the IMPAB that would be appropriate for children who use cochlear implants. The Iowa Music Perception and Appraisal Battery—Children's Version (IMPAB-C) was modeled after the Song Recognition and Appraisal Tests of the IMPAB, which is a computer-based test of musical perception, recognition, and appraisal that is designed for adults. Changes necessary in making this test appropriate for children included: shortening the overall length of the test, shortening the length of individual subtests, selecting developmentally appropriate musical stimuli, adjusting the language usage and content, and modifying the measurement tools.

Selection of ages. The test was designed for children ranging in age from 8–15 years. According to Piaget's stages of development, these ages will include children in concrete operations and in formal operations. In concrete operations, children are able to manipulate mentally the internal representations formed during the preoperational stage. They can perform mental operations, conserve quantity, and reverse their thinking. In formal operations, children are able to perform mental operations on abstractions and symbols. They can understand things without direct experience and are able to see the perspectives of others. The age range was selected for several reasons. One, extant research suggests that music preferences are established by Grade 4 (Greer, Dorow, & Randall, 1974). Two, children in Grade 3 and above can successfully use a Likert-type scale, which is the measurement tool used in the Song Appraisal Test (LeBlanc, Sims, Siivola, & Obert, 1996; LeBlanc, Jin, Simpson, Stamou, & McCrary, 1998; Montgomery, 1996). Three, this selection purposefully avoids children in high school, who may be strongly influenced by their peers and who have firmly established musical preferences.

Song Recognition Test. The purpose of this subtest was to determine whether children who use cochlear implants can recognize, by sound alone, songs that are well known to children in the

United States. The researcher created a list of potential song items for testing in two ways. First, extant research regarding commonly known children's songs was reviewed and a list of all songs from all studies compiled (Gfeller, et al., 1998; Humpal, 1998; Siebenaler, 1999). Second, local experts in the fields of music therapy and music education were asked to create a list of 10 songs that they felt all children would be able to recognize by age 15. A second list of songs was then compiled.

After creating a pool of potential items, the most suitable items were selected for use in the test. Criteria for item selection included the following: songs that received three or more "nominations" from experts (eight songs receiving four or more nominations are included plus one song that received three nominations) and songs that represented highly rhythmic (e.g., dotted rhythms, triplets, etc.) and nonrhythmic (e.g., even value quarter notes) structural features. Rhythm tends to be an important cue in song recognition for cochlear implant recipients. Four of the final selections are highly rhythmic in nature; five are nonrhythmic in nature.

A final item pool of nine items was selected for the test. Each song was repeated three times during the test for a total of 27 items. That list appears below.

Rhythmic items:

1. Happy Birthday
2. I've Been Working on the Railroad
3. Row Row Row Your Boat
4. Star Spangled Banner

Nonrhythmic items:

5. On Top of Old Smokey
6. She'll Be Comin' Round the Mountain
7. This Land is Your Land
8. Yankee Doodle
9. You Are My Sunshine

During the Song Recognition Test, the participant heard approximately 20 seconds of each song. Songs were played in a random order. The instructions were as follows: "You will hear 27 songs. After you hear each song, point to the picture or to the title

that matches the song that you heard." The participant was then to indicate the song that he/she heard from a visual array of four choices, that is, one correct response plus three distracters. The choices included a pictorial representation of each song as well as the title of each song. For example, the song "Happy Birthday" was illustrated with a birthday cake and birthday presents and with "Happy Birthday" printed beneath the illustration. Each test item was paired with one distracter that was similar in rhythm, one distracter that was similar in melodic contour, and one distracter that was different in both rhythm and melodic contour. In addition to the correct answer, one choice within each array of four was another test item and two of the choices were songs that are not heard during the test. In each repetition, the test item was paired with the same three choices. In each presentation, the choices were arranged in a random order. Nontest items appear below.

1. America
2. Down in the Valley
3. Home on the Range
4. My Bonnie
5. Old MacDonald
6. Take Me Out to the Ballgame
7. This Old Man
8. Twinkle Twinkle Little Star
9. When the Saints Go Marching

The instructions and format were pilot tested on a group of four normally hearing children ages 10, 12 (2 children), and 15. All children achieved 100% accuracy on this task. Three practice items were included in the IMPAB-C to clarify any confusion about the directions and expectations.

Alphabetical List of Song Titles. The purpose of the Alphabetical List of Song Titles was to determine which songs from the Song Recognition Test were previously familiar to each child, therefore eliminating errors due to unfamiliarity as opposed to perceptual inaccuracy. The Alphabetical List of Song Titles contains the titles for all songs pictured in the Song Recognition Test; it lists 18 song titles of which nine are actual test items. This tool was used to calculate a final adjusted score of percent correct on the Song Recognition Test. Participants were only scored for those items that they indicated they knew and that were familiar. From pilot testing, it

was determined that children sometimes fail to indicate on the list as familiar song titles that they clearly recognize during testing. Therefore, participants were also scored for any items that they did not indicate on the Alphabetical List of Song Titles but that they answered correctly at least two out of three times during the Song Recognition Test.

Song Appraisal Test. The purpose of this subtest was to assess musical appraisal and preference. Classical and nonclassical styles were used because these are two very different styles that have been examined in previous studies of musical preference for school aged children (LeBlanc et al., 1996, 1998; Siebenaler, 1999). There were two procedures used to select the classical items. First, extant research studying preference of classical music was reviewed and a list of all songs from all studies compiled (Hargreaves, Messerschmidt, & Rubert, 1980). Classical items used in the Song Recognition and Appraisal Tests of the IMPAB were added to this list. Experts/professionals in the fields of music therapy and music education rated each of the 22 items (using a 5-point Likert-type scale) on two dimensions: estimated familiarity and liking for children ages 8–15. Familiarity has been shown to be a strong factor in musical preference and was therefore considered important in item selection. The 10 items with the highest averaged scores are included in the Song Appraisal Test.

There were three phases in selecting the nonclassical items. First, a list of 60 items (20 pop, 20 rap, and 20 country) was created based on ranking in "Billboard's Hot 100" over a period of 8 months. Second, experts were asked to rate each item (using a 5-point Likert-type scale) on two dimensions: estimated familiarity and liking for children ages 8–15. Experts included radio personalities, DJs, parents, professionals in music therapy and music education, and people who work with adolescents. Several experts noted styles of music that they felt should be included in the item pool, specifically rock and hard rock. The 45 items with the highest averaged scores and with the inclusion of rock and hard rock examples were then compiled onto a CD. Third, 26 normally hearing children ages 8–15 listened to and rated each of the 45 songs using a 5-point Likert-type scale (1 = "like very much" to 5 = "dislike very much"). The rating scale included pictorial representations of the responses along the scale. The 20 songs receiving the highest average rating are included in the Song Appraisal Test.

The Song Appraisal Test includes 10 classical items and 20 nonclassical items. The nonclassical items represent a range of pop and rock substyles. Five classical and 10 nonclassical items repeat for a total of 45 items. Songs were presented in a random order. Participants heard approximately 20 seconds of each song. The instructions were as follows: "You will hear 45 songs. After you hear each song, point to or say the number that shows how much you like each song." Before beginning the test, the administrator explained the rating scale using nonmusical examples, such as foods or sports to ensure that the child understood the task.

The instructions, format, and test length were pilot tested with a group of 26 normally hearing children. All children appeared to understand the task; preferences were varied, as expected. In pilot testing, a combination Likert/pictographic scale was used. That is, cartoon faces with a continuum of positive to negative emotions were paired with the numbers 1 through 5. A face with a large smile accompanied the number 1, a neutral face accompanied the number 3, and a face with a large frown accompanied the number 5. When asked about the pictures, all children stated that they were helpful and made the rating process easier. Three practice items were included in the IMPAB-C to clarify any confusion about the directions and expectations.

Musical Background Questionnaire. In order to analyze the recognition and appraisal results in view of each child's past music education and informal music experiences, a questionnaire was developed. The questionnaire was modeled after the adult version of the Musical Background Questionnaire that is administered as part of the IMPAB. The purpose of this questionnaire was to determine the extent and types of musical training and exposure that children with cochlear implants experience. The questionnaire was pilot tested using a group of four normally hearing children ages 10, 12 (2 children), and 15 in order to determine the suitability of content and clarity of items.

Questions from the questionnaire are read to each participant much like an interview. This helped to eliminate possible misunderstandings due to reading skills. This further allowed participants to freely respond to questions and to communicate informally about their musical experiences and music listening habits. Sign language interpreters were provided for children with cochlear implants as needed.

Results

This section includes results from the children who use cochlear implants (both prelingually and postlingually deafened) and normally hearing children for song recognition, song appraisal, and musical experiences.

Song Recognition Test. Thirteen prelingually deafened cochlear implant recipients completed the Song Recognition Test. The mean number correct for the cochlear implant recipients was 8.29 out of a possible 27 items. Scores ranged from 3 to 17 correct. The standard deviation was 3.58; the variance was 12.84. The nonadjusted percent correct for the cochlear implant recipients was 31.48%; the adjusted percent correct was 42.01%.

The mean number correct for the normally hearing children was 24.94 out of a possible 27 items. Scores ranged from 20 to 27 correct. The standard deviation was 2.38; the variance was 5.67. The nonadjusted percent correct was 92.37%; the adjusted percent correct was 95.28%. *T*-tests comparing the two groups (prelingually deafened cochlear implant users and normally hearing children) revealed that the children who use cochlear implants were significantly less accurate ($p < .0001$) than the normally hearing children on song recognition.

Reliability estimates were also calculated using data from the normally hearing children. The value for Kuder-Richardson Formula 21, an internal consistency measure that estimates the reliability or relationship between individual test items, was 0.68. The split halves reliability, in which the test was divided into two sections and the two sets of scores correlated, was 0.54. Item difficulty was also calculated.

Item difficulty refers to the proportion of subjects who answer each test item correctly. The easiest item for normally hearing children was "I've Been Working on the Railroad." One hundred percent of normally hearing children answered this item correctly each time it was presented. The second easiest items were "Happy Birthday" and "Row, Row, Row Your Boat." The most difficult items for normally hearing children were "You Are My Sunshine" and "On Top of Old Smokey" (see Table 2).

The first postlingually deafened cochlear implant recipient, CI 4, achieved a score of 21 out of 27 correct. It is interesting to note that this score is comparable to scores of normally hearing chil-

TABLE 2
Song Recognition Test

	CI Children[a]	NH Children[aa]
Mean*	8.29	24.94
Range	3–17	20–27
SD	3.58	2.38
Variance	12.84	5.67
KR21		0.68
r_{TT}		0.54
Nonadjusted mean	31.48%	92.37%
Adjusted mean	42.01%	95.28%

[a] $n = 13$. [aa] $n = 32$.
* = $p < .0001$.

dren. The nonadjusted percent correct for CI 4 was 77.78%. This individual's score required no adjustment; this individual indicated on the Alphabetical List of Song Titles that he was familiar with all songs included in the Song Recognition Test. The second postlingually deafened cochlear implant recipient, CI 10, achieved a score of 10 out of 27 correct. Unlike CI 4, this score is similar to that of other cochlear implant recipients, although higher than the mean score for that group. The nonadjusted percent correct for CI 10 was 37.04%; the adjusted percent correct was 38.89%.

Song Appraisal Test. Thirteen prelingually deafened cochlear implant recipients and 32 normally hearing children completed the Song Appraisal Test. In this test, scores for each item range from 1 to 5, with 1 indicating most positive appraisal and 5 indicating most negative appraisal. The results for the cochlear implant recipients and for the normally hearing children appear in Table 3. The value for coefficient alpha, an internal consistency measure for scaled tests with no correct answer, was 0.84. *T*-tests comparing the two groups (prelingually deafened cochlear implant users and normally hearing children) revealed no statistically significant difference for the entire test. However, the difference approached significance ($p < .07$). When the test was divided and classical and nonclassical items compared between groups, children who use cochlear implants rated nonclassical items as significantly less likable ($p < .05$) than did the normally hearing children (see Table 3).

The ratings by the two postlingually deafened cochlear implant recipients were in general more negative than the prelingually

TABLE 3
Song Appraisal Test

	CI Children[a]		NH Children[aa]	
	All items	Per item	All items	Per item
Entire				
Mean	126.31	2.81	112.56	2.50
Range	66–185	1–5	74–151	2–4
SD	29.29	0.65	20.81	0.46
Classical				
Mean	40.36	2.69	43.34	2.71
Range	17–72	1–5	19–73	1–5
SD	18.67	1.24	14.66	0.90
Nonclassical				
Mean*	82.85	2.76	69.22	2.24
Range	49–134	1–5	40–125	1–4
SD	20.34	0.68	20.88	0.68
Coefficient Alpha			0.84	

[a] $n = 13$. [aa] $n = 32$.
* = $p < .05$.

deafened cochlear implant recipients. Again, higher scores reflect less preferred items. For the entire test, the mean score per item for CI 4 was 3.58, for CI 10 it was 2.93 (versus 2.81 for prelingually deafened cochlear implant recipients). For the classical items, the mean score per item for CI 4 was 3.67, for CI 10 it was 4.53 (versus 2.69). For the nonclassical items, the mean score per item for CI 4 was 3.53, for CI 10 it was 2.13 (versus 2.76).

Musical Background Questionnaire. Thirteen cochlear implant recipients and all normally hearing children completed the Musical Background Questionnaire. This questionnaire/interview includes questions related to musical involvement in school, music lessons, and everyday music listening habits, such as informal musical activities, favorite styles of music, favorite performers, favorite songs, etc. A summary of those results appears in Table 4.

Discussion

In summary, the purpose of this research was to answer the following questions. First, how do children who use cochlear implants compare with normally hearing children in terms of song recognition and appraisal (measured via the Song Recognition Test and the Song Appraisal Test)? Second, are there differences between

TABLE 4
Musical Background Questionnaire

	CI Children	NH Children
General music?	93%	100%
Band, jazz band, orchestra?	43%	38%
Choir?	14%	38%
Music lessons?	64%	72%
Do you listen to music at home or with friends?	100%	100%
Do you participate in musical activities?	93%	100%
Favorite singers/bands?	50%	94%
Favorite songs?	57%	75%

groups in terns of musical involvement, listening habits, and music preferences (measured via the Musical Background Questionnaire)?

In terms of the song recognition task, the cochlear implant recipients performed significantly less accurately than did the normally hearing children. In addition, there was considerably greater variability in the scores of the children who use cochlear implants. The two groups also differed in their test-taking behaviors. Normally hearing children recognized the test items and selected the appropriate answers almost immediately, listening passively to the remainder of each song. Cochlear implant recipients listened to the entire test item before beginning to select an answer and did not display obvious signs of recognition.

In terms of song appraisal, the cochlear implant recipients demonstrated greater dislike for all items on the Song Appraisal Test than did the normally hearing children. Cochlear implant recipients showed slightly greater preference for classical items than normally hearing children but significantly greater dislike for nonclassical items than the normally hearing children. There were also differences in terms of test-taking behaviors. As in the Song Recognition Test, normally hearing children responded to the test items almost immediately, indicating their level of preference quickly and definitively. Cochlear implant recipients typically listened to the entire test item before beginning to select a response. Once again, there was generally greater variability in responses among the cochlear implant recipients than for the normally hearing com-

parison group. This may reflect the considerable variability among implant recipients in general with regard to extent of implant benefit and user satisfaction, which is true for speech perception as well (Gfeller, et al., 2000).

Given the very atypical representation of musical sounds through a cochlear implant, it is interesting to see how similar children with cochlear implants were to normally hearing children in terms of self-reported musical involvement, listening habits, and music preferences (see Table 4). One hundred percent of the normally hearing children in this study listen to music at home or with friends and participate in musical activities, such as dancing, going to concerts, listening to CDs, and listening to the radio. Similarly, 100% of the children who use cochlear implants report that they listen to music at home or with friends and 93% report that they participate in musical activities. A greater interest in instrumental activities (compared to vocal activities) by cochlear implant recipients is not surprising, given the difficulty that many implant recipients report in matching one's own singing voice to an external pitch.

In conclusion, children who use cochlear implants are involved in a variety of musical activities. The children involved in this study report listening to music at home or with friends and further report participating in musical activities. In addition, the majority of cochlear implant recipients in this study take private music lessons. They are involved in music despite the fact that the implant is designed for speech perception. They are involved in music despite the fact that they performed less accurately than normally hearing children on a song recognition task and indicated greater overall dislike for music on a song appraisal task. Perhaps the social aspects of musical involvement and peer influence outweigh the negative or disappointing aspects of music listening. Perhaps children who have never heard music "normally" also develop a unique sense of aesthetic with regard to the beauty of music via the cochlear implant. Further research is warranted to more thoroughly investigate the factors that contribute to an implant recipient's musical involvement and enjoyment.

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