Preliminary Report of a Computerized Music Training Program for Adult Cochlear Implant Recipients

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A computerized music training program was developed for adult cochlear implant recipients that could be self-administered. The format and content of the training program was based on: (a) models of adult aural rehabilitation, (b) existing knowledge of music cognition and pedagogy, (c) models of adult learning, (d) feedback from implant recipients garnered through surveys and interviews with regard to music listening, and (e) data from a pilot study using a workbook and cassette tapes. Components of the training program are pitch sequence perception, song recognition, timbre recognition and appraisal, and appraisal of different musical styles. Pilot data suggest that structured listening experiences can improve music perception and enjoyment. Assessment of the program described is presently underway.

The cochlear implant (CI) is an assistive hearing device designed to enhance speech perception for persons who are profoundly deaf and receive little or no

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benefit from traditional hearing aids. Many implant recipients require some experience using the device before they achieve maximum benefit for speech perception. Possible factors that may contribute to improvement include reorganization of the central nervous system, processor adjustments or changes, additional learning opportunities, and aural rehabilitation programs (Tyler, Parkinson, Woodworth, Lowder, & Gantz, 1997). A number of aural rehabilitation materials are available for implant recipients, most of which represent an analytic approach, synthetic approach, or a combination of the two. Analytic approaches concentrate on developing an individual's ability to differentiate phonemes at a syllable or word level (Bruhn, 1949; Bunger, 1952; Kinzie & Kinzie, 1931; Plant, 1994; Walden, Erdman, Montgomery, Schwartz, & Prosek, 1981) while synthetic approaches provide practice in the recognition of everyday speech (Kaplan, Bally, & Garretson, 1987; Montgomery, Walden, Schwartz, & Prosek, 1984; Nitchie, 1930; Plant, 1996; Rubinstein & Boothroyd, 1987). Some programs are based on the premise that people use and benefit from both analytic and synthetic training and therefore include tasks representative of both approaches (e.g., Erber, 1988; Erber & Lind, 1994; Tye-Murray, 1997; Tye-Murray, Tyler, Bong, & Nares, 1988).

Because cochlear implants were designed to support spoken communication, the technical features of some current devices are less than ideal in encoding and transmitting musical sounds. For example, some devices extract only those formants especially salient for speech perception. Music often includes a much richer spectrum involving simultaneous presentation of several pitches (harmony) which may not be provided by feature extraction devices. Research indicates that, in particular, pitch resolution and perception of melody are difficult for many implant recipients (Gfeller & Lansing, 1991, 1992; Gfeller, Woodworth, Robin, Witt, & Knutson, 1997). Furthermore, implant recipients show significantly poorer recognition and appreciation of the timbre (tone quality) of musical instruments than do normally hearing adults (Gfeller, Knutson, Woodworth, Witt, & DeBus, 1998).

Even though the device is less than ideal for encoding and transmitting musical sounds, it is likely that most implant recipients are exposed to music in everyday life because music is such a pervasive art form in society (Radocy & Boyle, 1988). Anecdotal reports and questionnaire data indicate that some implant recipients are disappointed in or frustrated about the way music presently sounds via their implant and would like to enhance their present level of musical enjoyment (Gfeller, 1998). Other implant recipients, however, report that they do enjoy music. Many of these recipients required extended experience listening to music with the device or had to select suitable music and listening environments in order to achieve this benefit.

Given anecdotal reports that some implant recipients have attained musical enjoyment over time, improved music perception seems a reasonable goal for aural

rehabilitation. In addition, a number of implant recipients have expressed interest in enjoying music more than they have achieved through incidental exposure. Therefore, a music training program has been developed at The University of Iowa Hospitals and Clinics that can be used by implant recipients in their own home environment.

The primary goals of the training program project are: (a) to deliver a structured protocol, via personal computer, that will provide experience listening to various aspects of music; (b) to determine whether there are particular types of musical sounds or structures that are more accessible and enjoyable to implant recipients; (c) to assess whether a structured music training program can improve accuracy of music perception; and (d) to assess whether a structured music training program can improve musical enjoyment. Participants complete four, 30-min lessons each week for a total of 12 weeks. The music program is currently being evaluated by a sample of adults who have at least 12 months of experience using a cochlear implant.

Factors considered in the development of the program content and format will be described. Principles that were established for selecting content will be presented, as well as an overview of the program content and format. Finally, technical information regarding program development and delivery are reviewed.

FACTORS CONSIDERED IN PROGRAM DEVELOPMENT

Characteristics of Adult Learners

This program has been designed for post-lingually deafened adults ranging from approximately 25 years to 75 years of age. It has been well documented that adults have different needs and expectations than do school-aged children when it comes to learning (Merriam & Caffarella, 1991). For example, adults tend to prefer learning information that is meaningful and that has immediate usefulness (utility). Adults who have responsibilities at work and at home are more likely to persist in instruction that is easy to follow, reasonable in time demand, and readily available. Especially for older adults, there are physical and cognitive changes associated with aging, such as reduced visual acuity, or slower reaction time, that require accommodation. For example, the presentation format of material should facilitate ease of reading and comprehension. In the preparation of this training project, characteristics and needs of adult learners were reviewed (McLagan, 1978; Merriam & Caffarella, 1991; Seaman & Fellenz, 1989) and integrated into the program format and content.

Existing Music Appreciation and Music Theory Programs

Before developing the music training program, existing self-directed programs used for music appreciation and music theory were examined. It was determined

that the existing programs were unsuitable for the purposes of this project. For example, some programs have been developed for children and consequently, are not age appropriate in content or format. Other programs have been designed to develop technically-oriented aural skills in professional musicians who have excellent hearing acuity (e.g., recognition of harmonic structures used in musical composition, that have technical names such as a French 6th or Augmented 6th chord). Some programs present lengthy, complex examples of historically significant musical compositions and emphasize subtle compositional and stylistic elements (e.g., contrasting the compositional techniques used in the early and late string quartets of Mozart). Based on existing perceptual and questionnaire data (Gfeller, 1996, 1998; Gfeller, Knutson, et al., 1998; Gfeller & Lansing, 1991, 1992; Gfeller, Witt, Knutson, Coffman, & Woodworth, 1996; Gfeller et al., 1997), these sorts of instructional objectives are not realistic or appropriate for many implant recipients.

While the objectives and specific content of the existing music theory or appreciation programs do not seem compatible with aural rehabilitation objectives for implant recipients, research regarding efficacy of structured music training programs provides valuable information regarding factors that enhance learning and aesthetic enjoyment. Studies assessing efficacy of music training programs indicate that repeated exposure to the musical stimuli is the single most effective factor in promoting learning, perceptual accuracy, and enjoyment (Amen, 1977; Bradley, 1972; Heingartner & Hall, 1979; Radocy & Boyle, 1988). Consequently, the program was designed to distribute multiple repetitions of each item to be learned throughout 48 lesson modules.

Examination of Existing Aural Rehabilitation Programs for Speech Perception

Music, unlike speech, is non-discursive and conveys meaning very differently from verbal communication. Further, some of the components of aural rehabilitation programs, such as speech reading, are not relevant in some music listening situations (e.g., listening to music on the stereo). Therefore, we could not simply adapt an existing aural rehabilitation training program for speech by substituting musical examples.

However, research on music perception and cognition in normally-hearing people suggests that listeners attend to particular acoustical features, such as pitch changes (more similar to analytic theories of aural rehabilitation), but also use context and prior experience (more similar to synthetic theories of aural rehabilitation) as they listen to music. Therefore, the program was designed to include both analytic and synthetic listening tasks, as is the case for some aural rehabilitation programs for speech communication.

Research Regarding Music Perception of Normally-Hearing Persons

As noted above, existing research about how normally-hearing persons perceive and process music offers insight into the sorts of information useful in a music training program. For example, research regarding recognition of melodic sequences suggests that people attend to two different structural features: first, the magnitude of pitch changes from one note in the sequence to the next, and second, the overall contour (movement up or down) of the melody (Deutsch, 1982; Radocy & Boyle, 1988). Therefore, listening tasks that emphasize particular interval changes, as well as tasks that focus on the overall contour of the melody were included in the program. Other topics in the psychology of music relevant to this project include musical preference, affective response to music (e.g., rating or describing different musical selections and styles), timbre perception (e.g., recognition of different musical instruments), and sociocultural aspects of musical response (e.g., inclusion of songs often in everyday life).

Existing Data on Music Perception by Adult Cochlear Implant Recipients

While it is likely that implant recipients use similar cognitive processes as do normally-hearing people when listening to music, it is the case that the signal encoded and transmitted by the CI is significantly different from that heard through a normal ear, particularly with regard to melodic perception (Gfeller & Lansing, 1991, 1992; Gfeller et al., 1997). Therefore, what is known to date about the unique listening characteristics of adult implant recipients was considered when selecting objectives, content, and particular stimuli. For example, prior research indicates that adult implant recipients have similar perceptual acuity as normally hearing adults for basic rhythm patterns (Gfeller & Lansing, 1991, 1992). However, they have significantly poorer perception for melodic patterns. Therefore, rhythmic perception was de-emphasized, and a larger proportion of the program was dedicated to tasks emphasizing pitch-based aspects of music. Because research indicates that discrimination of small pitch changes is difficult or impossible for many implant users (Gfeller & Lansing, 1992), pitch perception tasks were sequenced, beginning with large pitch changes and gradually introducing smaller and more challenging pitch changes.

A Pilot Study on Music Training for Adult Cochlear Implant Recipients

Before investing extensive resources into a computerized training program, the content and format features of the current training program were piloted with implant recipients using cassette tapes and a companion work book (Gfeller, Witt, et al., 1996). Participants completed five, 30-min lessons each week for a total of 12 weeks. Included in the program were familiar and unfamiliar melodies, real-life musical excerpts representing four different musical styles, and brief computer-generated pitch and rhythm patterns. The musical examples were sequenced to move the listener gradually from very simple to more complex

stimuli.

Eight Clarion implant recipients completed the pilot program, and nine Clarion implant users served as controls. All participants completed pre- and posttests of perceptual and appraisal tasks. Subjective evaluations of the program clarity, content, and format were obtained from those in the training group.

Participants in the experimental training program improved accuracy for song recognition for unfamiliar songs (introduced in the training program) from 0% in pre-testing to 87% in post-testing. Control participants showed no improvement pre- to post-test on this same measure. The training group improved 25% in accuracy for recognition of familiar songs (e.g., "Happy Birthday," "When the Saints Go Marching In," etc.), compared to 18% for the control group. Thus, it appears that some improvement resulted from incidental learning, but improvement was considerably less than found in the training group (Gfeller, Witt, et al., 1996). These preliminary data suggested that cochlear implant recipients can improve some aspects of musical perception as a result of a structured listening program, though statistical analysis of a larger data set than that of the pilot project is desirable in order to formulate more conclusive findings.

All participants in the training group indicated that the program was clearly written and easy to understand. However, several requested more variety in the items over the 3-month period and more examples of different musical instruments in order to assist them in timbral recognition. Participants also commented on the cumbersome nature of rewinding the cassette tapes for each lesson in order to match the workbook pages with the correct portion of the tape. Several people noted that they would like to keep the tapes for future listening enjoyment, and one person commented that the program had helped him to identify those sorts of music listening tasks that are most realistic and enjoyable for him. Consequently, he is now better at selecting satisfactory listening materials in his everyday life. In response to this feedback, the variety of items in the current program was expanded and content on musical instruments was added. In addition, a computer-generated format in which the written information and music notation was presented simultaneously with the sound stimuli was developed.

PROGRAM CONTENT AND FORMAT

Because there are no existing music training programs for implant recipients, basic principles for selecting program content and format were considered during the development of the program. Taking into account that those using the training program would be postlingually deafened adults, the content and format that would best suit the characteristics of adult learners were selected. For instance, adults tend to prefer learning information that is meaningful and that has immediate utility (Merriam & Caffarella, 1991). One way to help adults develop an appropriate mental set for learning is to include an initial overview of the course ob-

jectives, upcoming activities, and future advantages of the program in the instructional materials (McLagan, 1978). In keeping with this principle, an opening lesson was included that contained the purpose of the program, the components of the program, instructions on how to use the program, and caveats about reasonable expectations for improvement. In addition, it was important to select vocabulary appropriate for non-musicians because most of our implant recipients do not have formal musical training. Therefore, the use of technical terms was limited and only basic musical terms were defined and included to help implant recipients to describe more clearly what they were hearing for research purposes.

It was necessary to select musical stimuli that represented the very large and diverse universe of musical sounds but yet were within a range of reasonable listening difficulty for implant recipients. In addition, it was important to present the content in a manner that would represent different aspects of perception and enjoyment, enhance learning, and promote program compliance. Therefore, the following principles were established: (a) select a combination of stimuli that represents basic structural features of music in isolation and in combination: pitch, melody, harmony, rhythm, and timbre; (b) select stimuli representing a range of simple to complex musical sounds; (c) select items representing a range of styles that tend to be enjoyable to many adults; (d) select tasks and musical stimuli with high utility in everyday life, such as "Happy Birthday"; (e) provide adequate repetition of information, balanced with adequate variety/novelty; (f) sequence the tasks, moving from highly-structured tasks to more self-directed tasks in order to promote generalization of skills into real-life; and (g) present stimuli in tasks that require a variety of processing skills: sound awareness, sound discrimination, closed-set recognition, and open set recognition.

The training program consists of 48 lessons, each approximately 30 min in length, to be completed over a 3-month time period (four lessons per week). Each lesson includes a 20-min portion delivered via the laptop computer and a 10-min listening segment delivered via CD player. The length of daily lessons was determined to be reasonable through pilot testing, and the 3-month time period was chosen in order to ensure distributed practice. The implant recipients who have participated in our field trials to assess program efficacy have been loaned the computer and sound equipment for usage in their own homes.

The content of the training program includes: introductory information about the purpose of the program; introduction of musical terms used in the program; simple pitch sequences accompanied by visual cues (pitch perception); images and sound samples of different musical instruments (timbre perception); practical listening tips from other implant recipients who enjoy music listening; computer generated versions of simple familiar songs (melody perception); computer generated versions of unfamiliar songs to be learned; excerpts of "real-life" music representing classical, country western, and popular styles of music; and self-directed exploratory tasks.

Pitch Perception Tasks

Because pitch and melodic perception tend to be difficult for many implant recipients, pitch and melodic perception tasks were included. Most of these items were paired with visual representations of the sound in order to assist the implant recipients in interpreting that sound (see Figure 1). Analytic items included identifying changes in pitch (e.g., the listener hears two pitches and determines if the second one is the same, higher, or lower than the first) that are initially large pitch changes and gradually become smaller and more difficult to discriminate. These patterns emphasize exact musical interval change, one factor believed to be important in melody recognition. The fundamental frequencies of these pitches presented ranged from 130 Hz to 784 Hz, those pitches commonly found in 4-part choral and piano music. More synthetic items included pitch changes embedded in familiar melodies (e.g., the listener is asked to listen to a pitch change and is told with written information that these notes are the first two notes in the song, "When the Saints Go Marching In"). The training program also included pitch sequences with differing contours (i.e., pitches moving up, down, or staying the same). The computer screen provides a visual display of the melodic contour while the sound stimuli are presented over the speakers, and the listener is instructed to follow the contour on the screen while listening.
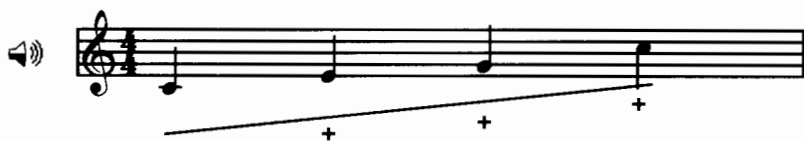

Figure 1. Musical stimuli paired with a visual representation of ascending pitches.

Timbre Perception Tasks

In response to feedback from implant recipients from the pilot study, and because timbre is a basic structural element of music, the sounds, images of, and information about commonly heard musical instruments were included. The musical instruments included represent four basic families of sound production: woodwinds, brass, strings, and pitched percussion. The instruments represent low-,

medium-, and high-frequency ranges. Various listening tasks were included to help familiarize participants with the instrumental sounds. For example, participants were asked to pair the different instrument sounds with name labels, discriminate between instruments, pick which instrument they thought was played out of a closed-set, appraise the various instrumental sounds, and use adjective descriptors to define the sound of each instrument.

Melody Perception Tasks

One musical skill common to most normally-hearing listeners is the ability to recognize familiar songs from melody alone. For example, most Americans would recognize songs such as "Happy Birthday" or "The Star Spangled Banner." Research indicates that melodic contour, recognition of exact intervals, and the rhythmic patterns all contribute to recognition (Deutsch, 1982; Radocy & Boyle, 1988). Because of the problems with pitch resolution commonly found in implant recipients (Gfeller & Lansing, 1991, 1992), song recognition can be difficult for implant recipients. However, some implant recipients report that they can sometimes recognize a song if it was familiar prior to hearing loss (Gfeller, 1998). One structural feature that implant recipients apparently use is the rhythmic pattern, if the tune has a strong rhythmic component (Schultz & Kerber, 1994). Given these factors, familiar melodies that are well known to the general public (as determined through prior testing, Gfeller, Witt, et al., 1996) and that are likely to be heard in everyday life (high utility) were included. In order to sample a range of structural features, while still providing some consistency in stimuli, songs representing the following structural features were included: songs that are highly rhythmic (e.g., dotted quarter notes, such as in the song, "The Star Spangled Banner"); songs that are primarily arrhythmic (i.e., notes of primarily equal duration, such as in the song, "Yankee Doodle"); songs in duple meter (2/4 or 4/4 time signature); songs in triple meter (3/4 or 6/8 time signature). All songs were presented in the same uniform key signature of C major. Each song is presented in two forms: melody only and melody plus harmony. This sampling helps determine if recognition is more difficult when harmony accompanies the basic melody.

Although implant recipients have reported that they often use prior familiarity with a song to help them with recognition, it is unknown if implant recipients are able to learn new songs, that is tunes that they first heard post-implantation. Therefore, a group of unfamiliar songs that were newly composed specifically for this project were included. Each unfamiliar song is a "reconstituted" version of one of the familiar songs described above. That is, the pitch and durational values of each song have been arranged in a different sequential order, while still maintaining structural rules of western harmony. Consequently, the songs are controlled for structural elements. Through this portion of the program, it can be determined if implant recipients are able to learn new melodies.

Through surveys of the implant recipients at The University of Iowa (Gfeller, Hanson-Abromeit, Knutson, & Witt, 1996) and national studies of the listening habits of American adults (Hoffer, 1992), it was determined that classical, country western, and popular music are the most commonly preferred styles of music for adults. In addition, reports from implant recipients indicate that prior familiarity with a particular song or musical style is helpful in processing and enjoying music. Songs familiar to the general public are also more likely to be heard in everyday life (high utility). Therefore, a group of actual excerpts from classical, country western, and popular repertoire were included in the program. Well-known items were identified through the following means: (a) examination of media polls and trade journals regarding media exposure of particular musical selections (e.g., *Billboard List of Top Ten Hits, Schwann Catalogue* of classical recordings); (b) ratings of song familiarity by experts in classical music, country western music, and popular music; and (c) ratings by naïve listeners of the relative familiarity of a pool of items.

However, because of the large memory requirements for recorded music, it is not presently realistic to deliver 3-min excerpts of the classical, country western, and popular song selections as a part of the program delivered via the laptop computer. Each training program participant will receive a specially prepared CD of these selections and a CD player.[1] This type of situation has the advantage of closely resembling everyday listening situations.

Self-Directed Exploratory Tasks

Experts on adult learners recommend that programs for adult learning include components that encourage active experimentation and that encourage application in real situations (McLagan, 1978). This helps maintain motivation and also helps the individual to generalize the information learned in the structured training program to real-life situations. Therefore, tasks that require interaction with the real-world listening environment were included. For example, the listener may be asked to tune their radio to two different stations having music and to describe the music on each station as well as determining if one sounds better than the other.

Through an article in *CONTACT,* which is a journal for cochlear implant recipients, and through interviews of implant recipients at The University of Iowa, information about how music sounds via the implant, problems, and practical suggestions for improving musical enjoyment were solicited (Gfeller, 1996, 1998). Analysis of the surveys revealed common experiences in music listening among implant users. These common experiences were presented in the program as tips from other implant recipients that they might want to consider.

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[1]Because this portion of the program includes the reproduction of copyrighted materials, we have sought legal advice on the proper use of copyrighted media in research and scientific projects.

PROGRAM DEVELOPMENT AND DELIVERY:
TECHNICAL INFORMATION

Musical stimuli for the training program were created using MIDI-based sequencing software. MIDI is an acronym for Musical Instrument Digital Interface, a serial data communications standard for connecting electronic musical instruments (e.g., synthesizers, drum machines, sequencers) to computers and other MIDI instruments. Just as word processing software permits electronic manipulation of text, MIDI sequencing software manipulates digitally encoded sounds. Sound files of the musical stimuli were created using the notational software feature in order to ensure precise control over timing, frequency, and waveform. The sound content of the files was converted to *AIFF* files, and the visual images of the musical notation were converted into *PICT* files. Authoring software was then used to integrate these various forms of information into the training program. Table 1 provides an overview of the authoring software that were required to integrate all the forms of information used in the program. Table 2 summarizes minimum hardware requirements for creating and delivering the musical training program.

PROGRAM EVALUATION

To our knowledge, this music training program is the first of its kind specifically for use by cochlear implant recipients. While pilot data indicated that structured music listening could be beneficial, that study included a small sample, and the scope of program coverage was more limited than this version delivered via personal computer. Evaluation of the training program is currently being conducted to determine the practical value of the program and also to help answer some more fundamental questions about implant recipients with regard to music perception and enjoyment such as: (a) to what extent does the complexity (e.g., melody alone vs. melody plus harmony) of the stimuli affect perceptual accuracy and appraisal; (b) to what extent do implant recipients make use of prior listening experiences in recognition and enjoyment (familiar vs. unfamiliar melodies); (c) can implant recipients learn new melodies (post-test gains in recognition accuracy for unfamiliar melodies); (d) are some musical sounds or structures more amenable to implant recipients (e.g., simple melodies, melodies plus harmony, different instrumental timbres, etc.); and (e) does structured listening practice improve listening enjoyment (post-test gains in appraisal scores).

Because the music training program taps a variety of musical tasks, evaluation of the program will be assessed using the *Iowa Music Perception and Appraisal Battery* (IMPAB; Gfeller, Witt, Kim, & Knutson, 1998). The IMPAB consists of a series of computerized tasks and paper and pencil surveys developed to assess a range of skills and attitudes with regard to musical perception and enjoyment for adult cochlear implant recipients (see Appendix). Implant recipients participating in the music training program will complete the IMPAB prior to instruc-

Table 1

Software Required for Creating the Music Training Program

Software	Description	Type	Format	Input File Description
Authorware 4.0	Authorware 4.0 is authoring software to create interactive multimedia applications using icon-based interface. It has two different interface screens: the Design Window and the Presentation Window. The Design Window is used for developing multimedia applications. Text, graphics, sounds, movies, and logic are integrated. The Presentation Window is for the use of viewing the actual multimedia interaction. After the application is packaged, users can run the package showing the Presentation Window only.	Text	RTF	RTF (Rich Text Format) is a form of encoding text formats for easy interchange between different kinds of word processing software.
		Sounds	AIFF	AIFF (Audio Interchange File Format) is a widely used audio format for Macintosh to store and transmit sampled sound. It can encode audio data in 8-bit (16-bit) mono or stereo waveform.
		Graphics	PICT	PICT (Picture) is a common format for Macintosh graphics. It supports both color and grayscale images with any size, pixel depth, resolution, and dimension.

Table 1 *Continued from previous page*

Software	Description	Type	Format	Description
			Input File	
SoundEdit 16 2.0	SoundEdit 16 is a sound-editing and signal-processing program for Macintosh. It supports creation and editing of multitrack audio data and allows users to store the audio data into various file formats such as SoundEdit 16, AIFF/AIFC, Windows wave (.wav), Quick Time and System 7 Sound (.snd). Every sound file was encoded by AIFF with compression to decreasethe size of the file and used 44 kHz for its sampling rate and 16 bits for its sampling size.	Sounds	AIFF	
Adobe Photoshop 4.0	Photoshop 4.0 is the tool for digital image processing. It supports editing images, controlling colors, and retouching existing photo images.	Graphics	PICT	

Table 2

Hardware Required for Creating and Running the Music Training Program

Hardware Requirements	
Creating the Program	**Running the Program**
• 68040 processor or faster, including Power Macintosh	• 68LC040 processor or faster (PowerBook 190/66 or higher)
• 16+ MB RAM	• 16+ MB RAM
• System 7.5.5 or higher	• System 7.5.1 or higher
• A monitor with 640 × 480, 256 color or higher	• 1 GB+ hard disk with 15 MB of available hard disk space
• A hard disk with 85 MB of available hard disk space	• Built-in speakers or external speakers for 16-bit stereo sound
• Built-in speakers or external speakers for 16-bit stereo sound	

tion and following the 3-month training period. The scores of those enrolled in the training program will be compared with pre- and post-test scores of a group of controls, implant recipients who have not participated in the training program.

CONCLUSION

In conclusion, the music training program was designed for adults who use cochlear implants and who have little or no formal musical training. The program includes exercises that focus on perception of isolated structural elements of music, as well as more naturalistic musical sounds within context. Pilot testing of a preliminary program indicate that structured listening experiences can improve music perception and enjoyment; assessment of the more extensive program described in the article is presently underway.

ACKNOWLEDGEMENTS

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APPENDIX

SUBTESTS INCLUDED IN THE
IOWA MUSIC PERCEPTION AND APPRAISAL BATTERY (IMPAB)

Timbre Recognition

Timbre Test Recognition (TT – Recognition). TT – Recognition assesses the ability to recognize, by sound alone, commonly heard musical instruments representing instrumental families based on sound production principles (brass, woodwind, pitched percussion, and string) in three different frequency ranges.

Timbre Appraisal

Timbre Test Appraisal – A (TT – Appraisal A). TT – Appraisal A assesses global or overall ratings of appraisal (likability) of commonly heard musical instruments representing instrumental families based on sound production principles in three different frequency ranges.

Timbre Test Appraisal – B (TT – Appraisal B). TT – Appraisal B solicits response to specific descriptors of the sound quality of musical instruments representing instrumental families based on sound production principles in three different frequency ranges.

Song Recognition

Familiarity by Complexity (FxC – Recognition). FxC – Recognition tests the ability to recognize, in open set and by melodic sequence alone (no lyrics), familiar folk songs presented in two levels of complexity: melody alone and melody plus harmony.

Song Recognition and Appraisal (SRAT – R). SRAT – R tests the ability to recognize, in open set, well known real-life recordings of musical excerpts representing three styles of genre of music: pop, country western, and classical.

Song Appraisal

Song Recognition and Appraisal (SRAT – A). SRAT – A assesses the appraisal or likability of a sample of pop, and classical songs.

Pattern Perception

Pitch Discrimination Test (PDT). PDT assesses the ability to identify correct target pitch.

Pitch Resolution Test (PRT). PRT assesses the ability to match the correct target pitch within the context of the songs "Happy Birthday" and "Jingle Bells."

Individual Client Characteristics

Musical Background and Appreciation Questionnaire (MBQ). MBQ assesses the nature of musical involvement, enjoyment, and style preference both prior to hearing loss and post-implantation in order to account for the effect of past musical training and listening experience on IMPAB scores. In addition, it identifies factors that contribute to either positive or negative musical listening experiences.

Alphabetical List of Song Titles (ALST). ALST provides information on the individual participant's prior familiarity with individual songs. This information is used in data analysis of the Familiarity by Complexity Test and the Song Recognition and Appraisal Tests.

Note. From *The Iowa Music Perception and Appraisal Battery,* by K.E. Gfeller, S. Witt, K.H. Kim, and J. Knutson, 1998, Iowa City, IA: The University of Iowa Hospitals, Department of Otolaryngology – Head and Neck Surgery.