# Aural Rehabilitation of Music Perception and Enjoyment of Adult Cochlear Implant Users

Kate Gfeller
*Iowa Cochlear Implant Research Center*

Maureen Mehr
*University of Iowa Hospitals and Clinics*

Shelley Witt
*University of Iowa*

Although structured music training for adult cochlear implant recipients can result in significant improvements in music perception, everyday listening experiences can be beneficial. Practical recommendations for enhancing music enjoyment for cochlear implant recipients based on the results of the field trials are outlined. Those structural features of music most amenable to rehabilitation are discussed.

## INTRODUCTION

The cochlear implant (CI) is an assistive listening device designed to support verbal communication, thus, the technical features of the device are particularly suited to transmitting those parts of the acoustical signal believed most salient to speech perception. Over the past decade, improvements in signal processing have resulted in impressive accuracy in open-set speech recognition following as little as 3 months experience with the implant in everyday communicative situations

Kate Gfeller, School of Music, Department of Speech Pathology and Audiology; Maureen Mehr, Department of Otolaryngology; Shelley Witt (now at the MEDEL Corporation), Department of Otolaryngology and the University of Iowa Health Care.

Correspondence concerning this article should be addressed to Kate Gfeller, Department of Otolaryngology, University of Iowa Hospitals and Clinics, 21201 PFP, 200 Hawkins Drive, Iowa City, Iowa 52242. Electronic mail may be sent via Internet to kay-gfeller@uiowa.edu.

(Tyler, Parkinson, Woodworth, Lowder, & Gantz, 1997; Tyler & Summerfield, 1996). These gains in speech recognition are due in part to the suitability of the implant for speech. In addition, most implant recipients have ample opportunity to practice speech recognition in everyday life, and to associate the sounds transmitted through the implant with visual cues (e.g., speech reading, closed captioning, gestures, body language, reading textual accounts, contextual cues, etc.).

Given the considerable improvements in the device with regard to speech recognition, implant recipients are now expressing hope that they can also enjoy music following implantation. According to Stainsby, McDermott, McKay, and Clark (1997), after speech perception, music appreciation is the second most commonly expressed desire among implant recipients. Unfortunately, current-day CIs are far from ideal with regard to transmitting salient features of music (Gfeller, 1998; Gfeller, Christ, et al., 2000; Gfeller, Knutson, Woodworth, Witt, & DeBus, 1998; Gfeller, Woodworth, Witt, Robin, & Knutson, 1997). Although implant recipients perceive basic rhythm patterns similarly to normal hearing adults (Gfeller et al., 1997), perception of implant users for pitch, pitch sequences, melody recognition, timbre recognition, and timbre appraisal (i.e., liking of the tone quality) is significantly poorer than that of normal hearing adults (e.g., Dorman, Basham, McCandless, & Dove, 1991; Dorman et al., 1990; Fujita & Ito, 1999; Gfeller et al., 1998; Gfeller, Witt, Stordahl, Mehr, & Woodworth, 2001; Gfeller et al., 1997; Gfeller & Lansing, 1991, 1992; Pijl, 1997; Pijl & Schwartz, 1995; Schultz & Kerber, 1994). Furthermore, greater perceptual accuracy and enjoyment of music is not strongly correlated with length of implant use. That is, music perception does not seem to improve as a result of general experience with the implant (Gfeller, Christ, et al., 2000; Gfeller, Witt, et al., 2002). These reports of poor music perception and enjoyment are unfortunate, given the pervasiveness of music in everyday life (e.g., concerts, TV, movies, radio, background music in places of business, religious and social events, as a marker of holidays, etc.).

While empirical studies regarding perception of pitch, melody, and timbre make musical enjoyment seem like an impossible dream to recipients of current-day implant users (Dorman et al., 1990; Gfeller, 1998; Gfeller et al., 1998; Gfeller, Witt, Kim, Adamek, & Coffman, 2000; Gfeller et al., 1997; Gfeller & Lansing, 1991, 1992; Pijl & Schwartz, 1995), it is interesting to note that some implant recipients have developed enjoyment of some aspects of music listening (Gfeller, Christ, et al., 2000). Some implant recipients report that music sounded distorted or unpleasant initially, but eventually they were able to develop appreciation and improved perceptual accuracy for some types of music as the result of focussed and repeated practice listening to music over many months or years (Gfeller, 1998). Although structured instructional listening tasks have resulted in significant improvements in listening perception, a number of beneficial music learning experiences can be found to some extent in everyday listening experi-

ences. The following practical recommendations for improving music listening are based on the reactions of CI users to the variety of experiences with music perception.

## PRACTICAL SUGGESTIONS FOR ENHANCING MUSIC ENJOYMENT

### 1) Establish Realistic Expectations for Listening

Current-day implants have been designed with speech perception in mind. As prior studies indicate, the device does not provide a typical representation of several important features of music, especially pitch (e.g., Dorman et al., 1991; Dorman et al., 1990; Fujita & Ito, 1999; Gfeller et al., 1998; Gfeller, Turner, et al., 2002; Gfeller et al., 1997; Gfeller & Lansing, 1991, 1992; Pijl, 1997; Pijl & Schwartz, 1995; Schultz & Kerber, 1994). Therefore, an implant recipient is likely to be disappointed if they expect music to sound the same as it did prior to their hearing loss, especially if they were recently deafened and have relatively recent and accurate recollection of musical sounds. For example, one implant recipient stated,

> Music is something I really miss, since I enjoyed it very much for most of my life. I'm beginning to wonder if some of my problems are that I lost fairly good hearing not too long ago, and still remember how things were and therefore *expect* better sound than I am now getting.

Establishing realistic expectations can take time. Another implant recipient who eventually re-established enjoyment of music stated:

> Initially, it was very disappointing to listen to music with my first CI. Newer and better processing strategies have helped, but I have had to adapt as well. Accepting a "new sound" in everything I now hear with my CI . . . extends to music. It can be extremely enjoyable to listen to music now with the CI, just as before my hearing loss – it's just different.

Unrealistic expectations may also result from incorrect recollection of normal hearing. Implant recipients who have had a lengthy period of deafness prior to implantation may have forgotten the limitations that normal hearing people experience in music listening. It may be useful to remind them that people with normal hearing also find some aspects of music difficult to understand (e.g., the lyrics to some rock music, or opera) and do not enjoy all types of music. Granted, these problems are more extreme for implant recipients than for normal hearing people, but reminders about the limitations of normal hearing can help in setting realistic expectations for the implant.

There is an additional critical point with regard to realistic expectations: As is the case for speech perception, there is enormous variability among implant recipients as well as intra-subject variability with regard to music perception and enjoyment. Therefore, it is unwise to presume that all implant recipients will

have similar success in music listening (either better or worse). Implant recipients are quite likely to compare their performance with that of other recipients they meet in person or on the Internet. In order to avoid unrealistic comparisons with reports of "star" implant users, remind each CI user that a variety of factors contribute to differing outcomes or profiles of improvement over time.

**2) Exploit Those Features Best Represented in the Initial Listening Practice**

In aural rehabilitation for speech, a therapist is likely to begin with exercises featuring sounds more readily perceived, and gradually add more difficult listening tasks as the client improves. The same principle can be used in music training. Help the CI user to select musical examples that include prominent use of structural features of music more easily heard through the implant. Some implant recipients, for example, will start by listening to the lyrics of songs, that is, speech information. However, sometimes, the simultaneous presence of background music can reduce clarity of the speech message, thus attending to the sung lyrics may or may not be a good starting point. This depends on the individual, as well as how clearly the lyrics stand out against the musical accompaniment in a given song.

As the introduction of this paper indicates, with regard to music, some structural features are easier for the implant recipient to perceive, and more amenable to improvement through structured listening experience. In particular, rhythm is more effectively transmitted through the device than timbre, pitch, or melody, but timbre is more effectively transmitted through the device than pitch and pitch-based musical structures such as melody or harmony. By exploiting those musical features best represented through the device, the implant recipient can get their rehabilitation experience off to a good start.

*Rhythm.* Because the rhythm is that structural element in music most accurately represented in the signal, initial attention to music might start with musical examples that have a clear and strong rhythmic beat. For example, often times, music in a country western or pop style has a dominant beat. Some classical tunes also have a clear beat. One strategy might be to have the listener focus on and follow just the beat of the music during initial exposures to a song, possibly tapping along with the beat to maintain attention, rather than trying to "make sense of" the entire musical gestalt.

*Timbre.* Timbral features, while less effectively transmitted by the CI than rhythm, are easier to perceive and improve than pitch. Recognition of different musical instruments and subjective ratings of sound quality can be significantly improved (though not equivalent to recognition accuracy for normally hearing non-musicians; Gfeller, Witt, et al., 2001) as a result of structured training (Gfeller, Witt, et al., 2002). In addition, listening practice of the sort used in this project can bring implant recipients within a similar range on appraisal ratings as

normal hearing adults on many instruments (Gfeller, Witt, et al., 2002). The task is for the CI user to relearn the sound of many musical instruments by pairing the new sound quality delivered through the implant with a cue regarding which instrument is being played (paired associate learning). This can be more difficult, however, if a given instrument is playing along with a large orchestra or band. Therefore, listening to solo instruments helps the listener to hear the spectral features of particular instruments.

Unfortunately, it is not always easy to find samples of solo instruments. One example of software that is available to the general public, and which presents solo instruments, is a CD-ROM titled *Musical Instruments,* created by Voyetra. This program has color pictures of musical instruments, a description of the parts as well as the history of each instrument, and examples of what each instrument sounds like.

*Pitch.* Pitch is the structural element of music that is particularly difficult for most implant recipients to perceive accurately. Thus, recognition of familiar melodies can be especially difficult. Implant recipients can sometimes piece together melody recognition of previously familiar songs by following the rhythmic pattern of the song, or by following any sung lyrics. Unfortunately, most implant recipients find it very difficult or impossible to learn new unfamiliar melodies by pitch pattern alone. For example, although the implant recipients enrolled in our music training program had multiple exposures to the newly composed songs, less than half were able to learn and subsequently recognize even one new melody (Gfeller, Witt, et al., 2001).

In summary, instruction such as this training program can help implant recipients to relearn the new sound of previously known songs (paired associate learning) to some extent, though the level of accuracy following training is still less than half of that for normal hearing adults (Gfeller, Turner, et al., 2002). Participants often noted that it was challenging to identify even those simple melodies that had been included in the training program. Thus it appears likely that for most participants, change in accuracy was not the result of improvement in fundamental perceptual ability for pitch perception, but rather a matter of developing compensatory strategies for recognition. Significant improvement may require fundamental improvements in how the implant transmits frequency information.

*Complex sounds (complex combinations of pitch, rhythm, timbre).* In interviews regarding music perception and enjoyment, implant recipients have often stated that they can more easily follow and enjoy music that is "less complex." However, it is not clear from these anecdotal comments what less complex means in terms of structural features of music. As a result of this training program, we have been able to test empirically the perception of musical sounds that vary in structural complexity, and determine the extent to which implant recipients perceive particular musical items as complex. For example, the simple melodies in

the familiar melody recognition test, which include only one instrument (the piano), no lyrics, and a basic representation of the melody line, are structurally much more simple than much of the music heard in everyday life, yet, these stimuli are very difficult for implant recipients to perceive.

In contrast, the complex songs in the program (recordings of real-life music) reflect to a greater extent than the simple melody task the sorts of musical stimuli heard in everyday life. These complex song items include a combination of melody, harmony, complex rhythms, timbres and timbral blends, and sometimes lyrics. Even though these real-life examples are structurally much more complex than the simple melodies, those in the training program demonstrated much greater improvement on recognition of complex than simple songs. From the standpoint of current-day implant characteristics, the rhythmic, timbral, and linguistic features of these complex song items are likely more accessible than is pitch information, which is the predominant feature of the simple melody task.

In short, the complex songs, as defined in this program are more amenable to structured listening practice. Thus, it appears that the implant transmits enough salient cues from the complex songs to permit learning new songs post implantation, though the percent of recognition accuracy is still only about two thirds that of normal hearing listeners (Gfeller, Witt, et al., 2001). However, some "real-life" songs have many concurrent musical themes or distorted or uncomfortably loud parts that can detract from listening enjoyment. Thus, it is important to use trial and error to find real-life songs that include readily perceptible features, but that are of optimal complexity for enjoyment.

With regard to appraisal (i.e., enjoyment) of complex songs, training seems especially effective in helping the implant recipients to enjoy the sound of classical music. This is a positive outcome, given that the classical items did not provide the linguistic cues of sung lyrics (as did the country western and pop styles). Following training, implant recipients compared favorably on appraisal ratings to those given by normal hearing adults (Gfeller, Witt, et al., 2001). Thus, structured listening practice to real-life musical excerpts can be very effective.

However, it may be important for the listener to approximate several aspects of our structured training program in order to make clinical significant improvement. These factors include adequate repeated listening to particular musical selections over time, some knowledge of or introduction to the instruments or style of the music in the excerpt, and focussed listening (as opposed to background music, that can easily pass out of the listener's attention). It may also help for the listener to select musical excerpts that they recall from prior to hearing loss in order to utilize context in "piecing" together the music.

### 3) Adequate Listening Experience is an Important Factor in Musical Enjoyment

When we analyzed the open-ended interviews of implant recipients who have independently re-established enjoyment of music, two common themes emerged:

First, music (or some types of music) started to sound acceptable to many of these respondents after 1 or 2 years of on-going implant use. Second, these individuals stated that they had to persist in focussed practice in music listening (not just letting background music "wash over them"). One implant recipient described this process as follows: "When I first got the implant, music sounded kind of flat, but now I can hear more 'layers' of the music, guitar along with voices, separate voices." Apparently, the experience with the device, as well as the focussed listening, contributed to acclimatization.

Unfortunately, for those individuals who initially experience aversive tone quality or music that sounds like noise (or worse – one patient described music as initially sounding like a cage of squawking parrots!), it can be difficult to persist in practice. In fact, some of our implant recipients report that they even stopped going to church because the music at church sounded so distorted.

In order to enhance the likelihood of compliance and persistence in listening, we integrated several factors into our training program. These are factors that have been successful in other forms of instruction with adult learners (Amen, 1977; Bradley, 1971; Gfeller, 2001), and which can be accomplished to some extent in a self-directed effort to improve music listening.

1. Begin practice sessions in an optimal listening environment. That is, listen with good sound equipment or to a live performance in a room that has little background noise or echo. For example, one implant recipient says, "Background noise is distracting." Another says, "I usually like quiet settings. Other noise distractions can cause me to become distracted when I'm listening to music."
2. Begin with short (possibly 10 to 15 min or even shorter if necessary) but frequently spaced rehearsals. Many people learn information more quickly through spaced (i.e., short frequent practice) as opposed to massed rehearsal (e.g., cramming for a test; Sternberg, 1999). These shorter sessions can also be helpful for those who have difficulty tolerating the initial sound quality of music. It may also help to reassure implant recipients that many people have required practice over time, and not to be alarmed if they do not have immediate improvement. Gradually, the listener can increase the length of practice, possibly trying to listen at least 30 min a day for 3 to 5 days weekly.
3. Listen to the same musical selections many times over many days. For example, one implant recipient recommends to "listen to certain music repeatedly, it becomes easier to follow." Repeated exposure seems to be the most potent factor in enhancing recognition as well as improved tone quality. It is not necessary to listen to entire symphonies (which can go on for as long as 45 min or longer). The lis-

tener may want to listen to short songs that are less than 5 min in entirety, or select 4-5 min excerpts of longer selections.

4. Vary the types of music chosen for listening practice. Because of intra-subject variability, some people may find particular musical tasks easier than others may. For example, some of our recipients really enjoyed listening to samples of solo musical instruments. Others had greater success listening to the complex real-life samples. Therefore, the listener may identify particular types of music that are best for them by trying a variety of styles or forms (e.g., solos, duets, chamber music, rock bands, larger orchestras, etc.).

**4) Use Context and Other Cues to Make Sense of the Sound**

Just as implant recipients tend to have better speech recognition scores on connected discourse than on isolated phonemes, so also do they tend to perform better on musical listening when they can use past experience and context to make sense of the sound. However, an implant recipient may not spontaneously use all the contextual cues available to them. They can be encouraged to use visual cues such as watching the lips of singers, or watching the arm movements of pianists or violinists for a general sense of the music's rhythm. For example, one implant recipient reports that she watched videos of Elvis Presley singing. She "just kept watching and listening" and then graduated to listening to that same music on the stereo without the visual cues. She also noted that it was easier to understand music she had heard before becoming deaf. In the case of vocal music on television, the listener can extract the lyrics by using closed captioning. For example, one implant recipient notes that he was able to extract the words to a Christmas choral concert on television through closed captioning. This gave him enough help to be able to follow and thus enjoy all aspects of the music.

Those implant recipients who read music may want to follow the notation (such as reading the music to the hymns in church), or they may even watch the overall contour of how the notes move (up or down) if they cannot read the notes. For vocal music, the song lyrics contained in the sheet music, or the lyrics provided with some recordings, can make useful visual guides during listening.

**5) Don't be Afraid to Experiment**

Those implant recipients who have achieved music enjoyment are persistent and tend to be effective problem solvers. They are not afraid to experiment and try out different sounds. For example, they will "mess around" with the volume and sensitivity settings on their processor. Some report experimenting with various processing strategies (ACE, SAS, CIS, PPS, etc.) on their external processors. Although many implant recipients have favorite strategies for everyday speech, and resist frequent strategy changes, it may be beneficial to experiment with different strategies for listening situations that are primarily music rather than

speech.

Implant recipients may also find suggestions from other implant recipients on web sites or in user journals such as *CONTACT*. What works for one implant recipient may or may not work for the next person, but some trial and error can help the individual find useful strategies for music listening. Also, trial and error can be helpful for finding music that is really pleasant. However, music should not be rejected too quickly given that some repetition is likely required to establish optimal enjoyment.

## SUMMARY

In summary, current-day implants are not ideal for music listening. Hopefully, technological improvements by the implant manufacturers will result in more normal sounding music. Meanwhile, these data indicate that some aspects of music listening can be improved with training, even with current-day speech processors that are less than optimal in transmitting salient features of music. As one implant recipient states, "I know the implant is getting better every year and the sounds will be much better in the future. I'm patiently waiting for that time to come. Until then, I'll continue to adjust to music over time."

Rehabilitative audiologists can assist implant recipients who are interested in greater music enjoyment by helping them target music listening tasks that are more amenable to rehabilitation and by helping them set more realistic expectations for listening enjoyment. Improvement does require focussed and repeated listening exposure, and, at present, some types of music are likely to sound better than others. The choice of optimal listening environments and particular listening tasks may help implant recipients to move beyond music as noise, to music as a satisfying part of life.

Although music may not sound normal as a result of training, if music can sound reasonably pleasant, the implant recipient may be more eager to attend various social events that include music (e.g., church, concerts, school programs, etc.), and which help them to connect with their family and community. As the wife of one of our program participants noted, at the completion of the training, her best Christmas present for the year was walking into the living room and seeing her husband once again listening to and enjoying orchestral concerts on public television, "just like he used to." She felt that she had gotten her husband back. While musical enjoyment does not have the obvious adaptive value (e.g., essential to survival in work and home) that we associate with speech and language, music, nevertheless, has a prominent place in society, and contributes to social integration as well as overall quality of life. Hopefully, judicious approaches to aural rehabilitation of music listening can play a role in restoring social integration and quality of life.

## ACKNOWLEDGEMENTS

This study was supported by research grant DC00242 from the National Institutes of Health/ NIDCD; grant RR00059 from the General Clinical Research Centers Program, Division of Research Resources, NIH; The Lions Club International Foundation; and the Iowa Lions Foundation.

## REFERENCES

Amen, B. (1977). *The effects of instruction in musical form on the musical attitudes of West German general music students.* Paper presented at the Music Educators National Conference, North Central/Southwestern Division Conference, Kansas City, KS.

Bradley, I.L. (1971). Repetition as a factor in the development of musical performance. *Journal of Research in Music Education, 19,* 295-298.

Dorman, M., Basham, K., McCandless, G., & Dove, H. (1991). Speech understanding and music appreciation with the Ineraid cochlear implant. *The Hearing Journal, 44*(6), 32-37.

Dorman, M., Smith, L., McCandless, G., Dunnavant, G., Parkin, J., & Dankowski, K. (1990). Pitch scaling and speech understanding by patients who use the Ineraid cochlear implant. *Ear and Hearing, 11*(4), 310-315.

Fujita, S., & Ito, J. (1999). Ability of nucleus cochlear implantees to recognize music. *Annals of Otology, Rhinology, and Laryngology, 108,* 634-640.

Gfeller, K. (1998). Music appreciation from the perspective of implant recipients. *CONTACT, 12*(3), 24-25.

Gfeller, K. (2001). Aural rehabilitation of music listening for adult cochlear implant recipients: Addressing learner characteristics. *Music Therapy Perspectives, 19,* 88-95.

Gfeller, K., Christ, A., Knutson, J., Witt, S., Murray, K., & Tyler, R. (2000). The musical backgrounds, listening habits and aesthetic enjoyment of adult cochlear implant recipients. *Journal of the American Academy of Audiology, 11,* 390-406.

Gfeller, K., Knutson, J.F., Woodworth, G., Witt, S., & DeBus, B. (1998). Timbral recognition and appraisal by adult cochlear implant users and normal-hearing adults. *Journal of the American Academy of Audiology, 9,* 1-19.

Gfeller, K., Turner, C., Woodworth, G., Mehr, M., Fearn, R., Witt, S., & Stordahl, J. (2002). Recognition of familiar melodies by adult cochlear implant recipients and normal hearing adults. *Cochlear Implants International, 3*(1), 29-53.

Gfeller, K., Witt, S., Adamek, M., Mehr, M., Rogers, J., & Stordahl, J. (2002). The effects of training on timbre recognition and appraisal by postlingually deafened cochlear implant recipients. *Journal of the American Academy of Audiology, 13,* 132-145.

Gfeller, K., Witt, S., Kim, K.-H., Adamek, M., & Coffman, D. (2000). A computerized music training program for adult cochlear implant recipients. *Journal of the Academy of Rehabilitative Audiology, 32,* 11-27.

Gfeller, K., Witt., S., Stordahl, J., Mehr, M., & Woodworth, G. (2001). The effects of training on melody recognition and appraisal by adult cochlear implant recipients. *Journal of the Academy of Rehabilitative Audiology, 33,* 115-138.

Gfeller, K., Woodworth, G., Witt, S., Robin, D.A., & Knutson, J.F. (1997). Perception of rhythmic and sequential pitch patterns by normally hearing adults and adult cochlear implant users. *Ear and Hearing, 18,* 252-260.

Gfeller, K.E., & Lansing, C. (1991). Melodic, rhythmic, and timbral perception of adult cochlear implant users. *Journal of Speech and Hearing Research, 34,* 916-920.

Gfeller, K.E., & Lansing, C. (1992). Musical perception of cochlear implant users as measured by the Primary Measures of Music Audiation: An item analysis. *Journal of Music Therapy, 29*(1), 18-39.

Pijl, S. (1997). Labeling of musical interval size by cochlear implant patients and normally hearing subjects. *Ear and Hearing, 18,* 364-372.

Pijl, S., & Schwartz, D. (1995). Melody recognition and musical interval perception by deaf subjects stimulated with electrical pulse trains through single cochlear implant electrodes. *Journal of the Acoustical Society of America, 98*(2), 886-895.

Schultz, E., & Kerber, M. (1994). Music perception with the MED-EL implant. In L.J. Hochmair-Desoyer & E.C. Hochmair (Eds.), *Advances in cochlear implants* (pp. 326-332). Manz, Wien.

Stainsby, T.H., McDermott, H.J., McKay, C.M., & Clark, G.M. (1997, September). *Preliminary results on spectral shape perception and discrimination of musical sounds by normal hearing subjects and cochlear implantees.* Proceedings of the International Computer Music Conference, Thessaloniki, Hellas.

Sternberg, R.J. (1999). *Cognitive psychology.* Orlando, FL: Harcourt Brace & Company.

Tyler, R.S., Parkinson, A.J., Woodworth, G.G., Lowder, M.W., & Gantz, B.J. (1997). Performance over time of adult patients using the Ineraid or Nucleus cochlear implant. *Journal of the Acoustical Society of America, 102*(1), 508-522.

Tyler, R.S., & Summerfield, A.Q. (1996). Cochlear implants: Relationships with research on auditory deprivation and acclimatization. *Ear and Hearing, 17,* 38-50.