The sound of music for adult cochlear implant recipients

BY VALERIE LOOI

Dr Valerie Looi has dedicated her academic career to investigating music perception in people who have cochlear implants, and more recently, the potential of music training for improving their music perception. This article outlines current research relating to music perception for patients with cochlear implants and offers some practical suggestions for clinicians working with this population.

Despite expeditious progress in cochlear implant (CI) technology resulting in most postlingually deafened adults being able to achieve excellent speech perception outcomes for quiet listening environments, accurate and enjoyable music perception still remains somewhat elusive for many. If we compare results for objective music perception studies from the 1990s to more recent results, we do not see the same steep trajectory of improvement that we observe for speech perception. Music perception results remain highly variable (some recipients do achieve extremely proficient levels and / or love the sound of music through their implant, whilst others avoid it altogether), and substantially poorer than for speech. Even more so than speech perception, the reasons for the variability and the predictive factors are unknown. Overall, accurate, enjoyable music perception, "just the way I remember," is still an unachieved gold standard for adult recipients and manufacturers alike.

There are four basic attributes to music – pitch, duration, loudness, and timbre. However, music perception is not just the ability to perceive these four attributes individually, but also the interactions between them. The range of fundamental frequencies and dynamics (loudness) for music are far greater than for speech, and the amount of redundancy in the stimuli is far less. Further, timbre and sound quality in music has a far greater role in contributing to the overall experience than it does for speech. Whereas the main role of speech perception relates to communication and getting a message across, the role of music can extend far beyond getting a message (or melody) across, transcending psycho-social, emotional, social, and quality of life domains. For example, music may create a mood, or we may listen to it to relax or feel energised, and / or associate certain events or emotions with a piece.

Research to date has shown that for adults, the amount of time spent listening to music post-implantation is usually significantly lower than when they had better hearing, and many recipients report music to sound strange, tinny, mechanical, unnatural and noisy. It is well accepted that from a perceptual accuracy point of view, adults with CIs perform similarly to adults with normal hearing (NH) or hearing aid (HA) users on rhythm tests, however score significantly lower than NH listeners on pitch based tasks, including pitch perception and melody recognition tests [1,2].

Another key feature of music is timbre. Unlike pitch and loudness, timbre is multidimensional, related to differences

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in sound spectra. It is the feature that enables us to differentiate between two different instruments playing the same note at the same volume and is usually assessed using music instrument identification and sound quality rating tests. It is important to note that identification and appreciation are different. Just because you can name a song does not necessarily mean you like it, and conversely there would be songs you have heard and liked, but not necessarily known the name of. Both tasks depend on a host of factors including those related to the stimuli parameters directly (e.g. waveform envelope, temporal characteristics), as well as variables associated with the music (e.g. the number of music lines or parts, style or genre, complexity etc.) Again, CI recipients score lower than NH listeners on identification tests, as well as rate the instruments to sound poorer in quality than their NH counterparts [1,2]. Gfeller *et al* found that CI recipients scored significantly lower than NH listeners in recognising and appraising the sound quality of eight different instruments [3]. Speech perception did not correlate with recognition or appraisal, and there was no significant correlation between identification and appraisal scores, supporting the notion that these are two different concepts. For CI recipients, higher frequency instruments were perceived to be noisier and duller than for NH listeners.

It is important to keep in mind, though, that CI recipients have a significant sensorineural hearing loss, and comparisons to NH listeners may not be

fair or equitable. Looi *et al* compared CI and HA users with similar levels of hearing loss (i.e. the HA users met the audiological CI criteria) in tasks of pitch, melody and timbre perception [4]. For pitch, they found that the CI recipients were significantly worse than HA users, but HA users were also significantly poorer than NH listeners. As a group, the CI recipients were unable to tell which note was higher when the notes were 3-semitones (1/4 octave) apart. They were also significantly worse than the HA users at recognising familiar melodies. Interestingly, though, there was no significant difference between CI and HA users on either instrument or ensemble identification tests, and when asked to rate the sound quality of the stimuli, the CI recipients provided higher ratings than the HA users, suggesting that music sounds more pleasant with the CI than when compared to the time just prior to implantation when they had a moderately-severe to profound bilateral hearing loss and used HAs [5].

There is no indication when you evaluate objective, non-manufacturer-sponsored research, that one type of CI and / or manufacturer, or any specific speech processing strategy is better or worse for music. Gfeller *et al* retrospectively analysed results from 209 recipients for factors which may predict music perception and appraisal [6]. They found different sets of predictor variables for perception versus appraisal tasks. However, device type or speech processing strategy was not a significant predictor for any task. The only consistent correlations between music perception and a variety of subject variables across research studies have been for the factors of age (younger recipients score higher), post-implant (or 'current') music listening habits, and the use of a contralateral HA [1,7].

Collectively, research suggests that electrical stimulation of hearing does not allow a recipient to fully appreciate musical stimuli. This is due to a combination of factors including the sound processing of a CI, patient factors (e.g. auditory neuron survival rate and pattern), current spread in cochlea, properties of the input signal, and perceptual limitations of the recipient [2].

So, what can we do?

However, do not be disheartened – it is not all negative! What can you do as a clinician?

Music training and focused listening practice has been shown to help, both when compared to a control group, as well

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as when compared to pre training scores [7]. As research has shown no correlation between how long a patient has had their CI for and their music perception or appreciation scores, this indicates that incidental exposure is NOT enough, and hence, focused music listening practice and training is required. This is further supported by the earlier-mentioned finding that post-implant music listening habits correlate with music perception scores (i.e. more music listening is associated with better scores). It is worthwhile considering when counselling recipients that, with speech perception, although they may not feel that they have completed a specific 'training programme' per se, and yet improved in their speech perception abilities, they are in fact practising this every day using focused listening practice. Whenever they are talking to someone else, they are focused on the conversation with the goal of understanding what the other person is saying, and training themselves to understand the sound(s) they are hearing. For music, however, it is usually in the background, and 'focused' listening (i.e. where they sit down and concentrate on the music stimuli to try and determine what they are hearing in an analytic manner) is rare, and nowhere near as much as for speech perception. (*See the appendix for some self-directed learning exercises that you could give to your clients to try, and / or work through with them as part of their rehabilitation plan.*)

Additionally, the use of a contralateral HA if the recipient has aidable levels of residual hearing, has been shown to help with music listening. The contralateral HA may not enable functional speech perception (e.g. 0% open-set speech perception score, HA only), but may

still provide significant improvement for music, compared to CI only. Hearing aids provide more reliable fundamental frequency information than CIs to enhance pitch perception, whilst the CI provides additional high frequency information, hence combining the two devices may be beneficial if the patient has sufficient low frequency residual hearing [1,2].

Setting realistic expectations is important. It is interesting to consider that when we evaluate speech perception outcomes for adults, we consider a successful outcome to be when a patient scores higher with their CI than what they scored just prior to surgery in their best aided listening condition. We do not consider a successful outcome to be only if a patient performs similarly or better with their CI than when they had normal hearing! Our determinants of success are through comparisons made back to results obtained when their hearing and speech perception thresholds put them in the CI candidacy range, not to when they had no hearing loss and normal speech perception. However for music, the criteria for 'success' has been benchmarked to music perception with normal hearing. Is this realistic? Are we setting up our patients with (at least, as yet) unachievable expectations? As a clinician it may be worthwhile considering administering objective and subjective (quality rating) music tests just prior to implantation, when the patient is still using HAs, just as you would for speech. These tests could then be readministered after implantation (e.g. at 12 months or later) to look at the impact of cochlear implantation on music perception. This may be particularly valuable with patients for whom music is an important part of their lives, as the information could provide a more realistic and useful guide for counselling, and also for determining rehabilitation plans.

Finally, do remember that some recipients love music, and are successful with it. For example, compared to pre implant, CIs may provide more high frequency information, and recipients are able to hear more than just the 'beat' (i.e. the louder, low frequency components that may have dominated with HAs).

Summary

'Normal' music perception is a commonly expressed desire for many adult CI recipients, and an as yet unattained goal of CI manufacturers. Research to date indicates that postlingually deafened adults with CIs perform similarly to adults

with NH on rhythm perception tasks, but poorer on tasks involving pitch and timbre perception, regardless of what type of CI or speech processing strategy they use. They also rate music to sound poorer, which is often then reflected in their quantity of music listening with the implant. When compared to HA users with similar levels of hearing loss, though, the difference in scores is far less disparate. Encouragingly, research also indicates that recipients can improve their music perception and appreciation through music training and focused listening practice, as well as by using a contralateral HA if they have aidable levels of residual hearing. Music perception and appreciation needs persistence and practise. So if there is one take away message to pass onto your patient – 'Don't give up, and always think CI can!'

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Declaration of Competing Interests

Valerie Looi was employed by Cochlear from 2011-2013 and holds shares with the company. However, none of the work discussed in the article was undertaken, influenced by and / or financially supported by Cochlear.

ABOUT THE AUTHOR

Valerie is both an audiologist and a registered music therapist. Her PhD in Audiology from the University of Melbourne investigated the music perception of cochlear implant (CI) recipients compared to hearing aid users. After working at the University of Canterbury in NZ, as a Senior Lecturer in Audiology for five years, she moved back to Australia. She is currently the Senior Research Manager for the Sydney Cochlear Implant Centre (SCIC), where she has been for the last three years.

Her research has focused on the music perception and appreciation of CI recipients, and more recently, on developing music training programmes, as well as lexical tone perception, quality of life, and clinical outcomes for CI recipients. She has published over 30 peer-reviewed papers, and made over 35 oral conference presentations, including 10 as an invited speaker.

APPENDIX – Self-directed learning exercises for music

Things adult CI recipients can try if they want to reintroduce themselves to music, or to work on improving their music perception and/or enjoyment.

♫ Try listening to exactly the same piece using different play back modes. For example, try listening to that piece on your stereo, on the computer, with an MP3 / ipod or other portable music player. Try it with earphones, speakers and / or direct audio input etc. Which one do you prefer? Why? What sounds different between the different modes? What can you hear with one mode that you can't hear with another mode (and vice versa)?

♫ Try listening to two CDs of styles you have never listened to, or would not normally listen to. Compare the two styles, and compare them to what you normally listen to. What is similar, what is different? Which sounds better? Why? What features are more prominent in one style over another? What elements of the new styles do you like / dislike? Why?

♫ Try listening to two Asian or Eastern music pieces (or two pieces from a different culture that you've never listened to before) and describe what you hear. Which features of the music are more distinctive, which are less distinctive? What sounds different? How does it compare to the music you normally listen to? Do you like it or not? Why / why not?

♫ Try listening to two radio music stations you've never listened to for 30 mins each, and describe the music played on each station.

♫ Listen to two different CDs (two different artists) in your preferred style. Select two groups / bands / artists / composers you've never listened to before. Have contrasting CDs (e.g. different instrumentations, or different types of music in that style). For example, if you like classical music, contrast orchestra vs. chamber music, or romantic vs. baroque, or 20th century vs. 1800s, or choral vs. opera, or wind vs. strings, etc. If you like jazz, contrast blues vs. swing, or instrumental vs. vocal etc. If you like pop / rock, try contrasting pieces from the current top 40 vs. 1960s or 1980s, or heavy metal vs. rock, or a single artist vs. a group etc.

♫ Compare your everyday listening programme to a specific music listening programme (MAP) on your CI, whilst listening to three different pieces (i.e. listen to the same piece with both programmes). Write down the differences and similarities between the two programmes / MAPs. Do you hear any differences in the sound quality (timbre) or pitch? Does one sound more / less in tune than the other? What features of the music are more / less prominent with one MAP than the other? Also try listening with features such as auto-sensitivity or noise-cancelling techniques on and off. Does that change anything? Do any of the musical features become more / less prominent?

♫ Try to find the same song recorded in a variety of instrumentations or in a number of different ways, even if it's a simple folk song, nursery rhyme, Christmas tune, etc. For the song, try to find: a solo instrument version (melody only, no lyrics); a version with a singer (i.e. with lyrics) and simple accompaniment (e.g. piano or guitar); a karaoke version where there are subtitled lyrics; a larger group version (e.g. band) of the song with lyrics; and an instrumental-only larger group version. (YouTube might be a good starting point). Start with the simplest recording and work your way up in complexity. This approach could be used to learn new songs (or relearn old songs). Find the simplest version you can, then as you become familiar with the piece, find more complex or sophisticated versions. Note which versions you prefer and why. What features of the music are particularly helpful for you in learning (or recognising) the piece of music?

♫ If you can get access to a keyboard or piano, try experimenting on it. For example, start with the lowest note and go up the notes progressively one by one. Do you hear an increase in pitch for each subsequent note, or is there a series of notes that all sound the same, or do some of the notes sound 'out' or wrong in pitch? What happens as you get to the right side of the keyboard (i.e. the highest notes)?

Suggestions for clinicians:

• The suggestions above are just a starting point – you may have additional ones you could add, and / or have used.

• Select a few of these activities that seem most suitable and feasible for your patient, and then order or prioritise them depending on their abilities, interests, skills, resources, time available, music preferences, goals, etc.

• Try to develop a structure around them – e.g. tell them how long to do each activity for, how many times to do it, how often to do it. Make it into, or as part of, a rehabilitation programme for them.

• Guide them on where to find the resources (e.g. YouTube, Spotify or another music streaming software, different apps, public libraries, their own music collections, etc).

• In all of these tasks, encourage your patient to be analytic in their listening. That is, don't just say if they like it or not, but why or why not? What is different about the music? What elements or features of the music are less or more prominent? Ask them to describe the sounds they hear as if they were trying to explain it to someone without an implant. What does it sound like to them?

• Give them a diary or note book to record their progress, thoughts, etc. For each session, get them to also note what pieces they listened to, where they were listening to it (e.g. at home in the loungeroom, in bed with their ipod, etc), what mode of playback they were using (e.g. speakers, direct audio input, etc.), what device settings they were using (volume / sensitivity level, programme number ,etc.), if there was any background noise or other distractions or people present at the time, etc.

• You could write out a specific list of questions for them to answer for each activity.

• Take the time to read their responses and their diary, and question them about what they wrote, or challenge it if you think they could provide more detail. You could give them follow-up questions to answer. The more precise, descriptive, and systematic they can be in their descriptions, the more attention they're paying to the music. Also, see if they report anything regarding the sound quality that could assist you in counselling, or in creating a music listening programme / MAP.

• You could also start to compile a list of music, songs or pieces that your patients have said they enjoy, find easier to recognise or follow, sounds pleasant, or have found as a good starting point, etc. – that is, a list of pieces that your patients would suggest to other recipients as a good starting point for music listening. Classify the pieces into different genres or styles so patients can choose pieces in their preferred style. If you document any relevant information and suggestions from your patients, over time you will start to have a list of pieces that you can pass onto other recipients as recommendations from their fellow CI users. Ask the patients why they recommend the piece(s) they have, and note this down – this provides hints to other recipients on what they may want to focus on initially in that piece. Try and listen to the recommended pieces yourself, if you have time. Obviously, make sure you counsel to the recipients that these are just suggestions from other recipients – they may or may not like them, and / or they may notice, hear or think something entirely different!