‘Like Pots and Pans Falling Down the Stairs’. Experience of Music Composed for Listeners with Cochlear Implants in a Live Concert Setting

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Abstract

This study investigated whether music specially written for people with cochlear implants (CIs) could be used to better pinpoint how the music listening experience for a CI was different to a normal hearing listener (NH). After the specially arranged live concert, focus groups were formed from audience volunteers (two groups each of CIs, NHs and a range of hearing assistant devices). The theme of musical features (MF) was reported most frequently for both NHs and CIs. Valence analysis identified no significant difference in positive comments about MF by CIs than NHs for the specially commissioned works. Spatialization, although reported infrequently, was considered important by some CI, NH and bimodal listeners (who use a cochlear implant and a hearing aid). Rhythm was enjoyed by both NH and CI groups, and percussion instruments liked more than other musical instruments, but more so by CIs. Bilateral and bimodal CIs expressed interest in optimizing the hearing assistance settings, but on several occasions, the optimization ended with turning the contralateral hearing aid off. The study identifies the possible critical role of familiarity in music enjoyment.

Keywords

Cochlear implant, perception, aesthetics, composition, live music

1 Introduction

Jump to section

With over 30 years of technological advances, individuals with cochlear implants (CIs) are able to understand speech relatively well, with average speech

understanding scores reaching 80% in quiet, even with some background noise, and with one or two speakers (Gifford, Shallop, & Peterson, 2008). In terms of the cochlear implant technology this success with speech, such as sentence recognition without background noise has reached a plateau since around 2001 (Fu & Galvin III, 2011), but despite the success of the implant in decoding speech, CIs have barriers that have not been considered as important because of the primary goal of providing a majority of hearing impaired people with improved speech perception. As Fu and Galvin remonstrate 'unfortunately, even state-of-the-art CI technology has shown only limited success in improving performance for poor CI users or for good CI users in difficult listening conditions (e.g. speech in noise, music perception, etc.)' (Fu & Galvin III, 2011, p. 258). The focus of the present paper is on the lacuna of music perception for CIs. Despite the success of the implant in processing speech, surveys have reported a strong desire for CIs to have improved music processing capabilities, which are generally considered poor for those with memories of music in previous normal hearing periods of their lives (Looi & She, 2010; McDermott, 2005; Mirza, Douglas, Lindsey, Hildreth, & Hawthorne, 2003; Nimmons et al., 2008). Current cochlear implant technology allows listeners or their audiologist to adjust the processor program which converts acoustic sounds into electrical pulses that are transmitted to the implanted cochlear electrode array. While some research has sought to identify the program that best suits music (e.g. Looi, Winter, Anderson, & Sucher, 2011), considerable amounts of research focus on adapting other parts of the environment and the individual in order to enhance the music listening experience. To date, such solutions can be groupedinto two branches: (1) complementing existing technology and (2) listener training. The literature on complementing existing technology has identified how existing technology can be better used to enhance the music listening experience. For example, melody perception for CIs has been shown to improve by the contralateral (ear without the implant) use of a hearing aid (HA) (Kong, Stickney, & Zeng, 2005; Looi & She, 2010; Philips et al., 2012). Looi and She (2010, p. 126) summarize this approach as *both is better* through a comment made by one of their participants: "'organic hearing rounds out the sound and provides additional cues (particularly low frequencies).' This is consistent with numerous other studies which have demonstrated the benefits of bimodal hearing over the CI-alone, for a range of listening tasks."

Listener training, on the other hand, is based on the hypothesis that practice in music listening or music related exercises will enhance CIs' music listening experiences because neural re-organization will take place. Fu and Galvin III (2011, p. 257) point out that 'the success of the [cochlear implant] would not be possible without the plasticity of the human brain', while Gfeller, among others, reports correlation with amount of listening and success of music perception and appreciation (Fujita & Ito, 1999; Galvin III, Fu, & Nogaki, 2007; Gfeller, 2001; Gfeller, Woodworth, Robin, Witt, & Knutson, 1997). Several researchers have developed and tested training programs to help CIs better process and appreciate music stimuli (Chen et al., 2010; Galvin III et al., 2007; Gfeller et al., 2000; Gfeller, Witt, Stordahl, Mehr, & Woodworth, 2000). For example, one of the first systematic music training programs for CIs (Gfeller, Witt, Kim, Adamek, & Coffman, 1999) consisted of pitch, timbre and melody perception studies over a period of 12 weeks. The pitch tasks were combined with visual cues (such as a rising line accompanying a rising melodic contour), the timbre tasks with images of musical instruments, and the melody tasks were a mixture of familiar, high utility melodies (like 'Happy Birthday'), and unfamiliar melodies. This pioneering study, like many of its successors, demonstrated improvements in music perception compared to control CIs who received no training (see Looi & She, 2010).

The two branches of complementing technology and listener training have led to significant improvements in music perception and enjoyment in CIs, but the results have yet to reach levels comparable to speech perception. Furthermore, and of greatest relevance here, both branches aim mostly to seek music listening experiences that are grounded in the most normal post-lingual hearing experiences those individuals had prior to implantation. In contrast, our research is exploring the possibility that the cochlear implant, while hindering and closing off some listening experiences, may be opening up new, as yet uncaptured musical opportunities.

Thus, our research program has focused on developing a third branch of broadening musical experiences for CIs—specially composed music. This branch requires the music creator to have a good understanding of how CIs process audio, and the inherent limits of the implant's capabilities. To this end, authors HI and JM commissioned contemporary music composers to work closely with cochlear implant scientists and CIs in developing new compositions that CIs may be able to

appreciate. In a special concert in which six commissioned pieces were premiered, the audience was invited to participate in a data gathering exercise to help us better understand the success or otherwise of the specially composed music, and to see what issues emerged as a result of the experience. An implicit goal was to observe whether CIs engaged with and reacted to the music as normal hearing listeners (NHs) might. That is, to identify the CI experience, we wanted to observe whether from their post-concert comments they engaged and persisted with the music, and to describe similarities and differences with NHs in a live concert music setting. Our method has the disadvantage of reducing possible past associations, including social connection, that may enrich a musical experience e.g. Juslin & Västfjäll, 2008). In this respect, this third branch is exploratory.

Previous research methods, including our own (Au, Marozeau, Innes-Brown, Schubert, & Stevens, 2012), have focused on collecting responses about musical experiences via questionnaires (often relying on rating scales and open-ended questions), and in the case of music training programs, examining correct or incorrect choices under quiz-like conditions. Surveys have developed into highly sophisticated tools for collecting data on music experiences for CIs, perhaps most impressively culminating in the 48 item University of Canterbury Music Listening Questionnaire developed by Looi and She (2010). The questionnaire was based on listeners' memories of musical experiences, and consisted of seven sections labelled (1) Music listening and musical background; (2) Sound quality; (3) Musical styles; (4) Music preferences; (5) Music recognition; (6) Factors affecting music listening enjoyment, and (7) The music training program. The questionnaire consisted of rating scale items and open-ended responses, and was developed through three interviews with a range of cochlear implant experiences. Our own research, also using rating scales, required listeners to rate cognitive aspects of the music (including interest and understanding), technical aspects (such as localization, and instrument identification) and matters relating to the listeners' engagement with the music (musicality and enjoyment) of the six specially commissioned pieces (Au et al., 2012).

While rating scale responses allow for convenient, sophisticated statistical analyses, the scale items are necessarily predetermined and require the researcher to limit the scope covered (Andres, 2012). Unlike many qualitative techniques, this exposes

research to the risk of missing underlying, important issues in music perception that CIs are experiencing; written responses may also limit the report of the range of peoples' reactions. To address this possible limitation, we employed a focus group approach. Focus groups frequently consist of small groups of about 5 to 10 people with similar interests to discuss issues on a topic (for detailed discussion on group size and other key issues in focus group research, see Barbour & Kitzinger, 1999). Analysis of qualitative data obtained from focus groups supports the emergence and consensus of matters through the in-depth discussion that such groups encourage (Krueger & Casey, 2009), within an appropriate social context which is usually absent in survey responses (Barbour & Kitzinger, 1999; Macdonald & Wilson, 2005).

Therefore, a study was conducted to examine responses of CIs to music, and in particular to specially composed new music, in order to expand previous research on music perception in CIs from an experience broadening perspective. Furthermore, we wanted to explore an open-ended data collection method via a focus group data collection strategy.

2 Aim

The broad aim of our research program was to determine what the pertinent issues were for CIs when listening to live music composed with the intention of having a CI audience. We seek to continue novel, interdisciplinary approaches to understanding how cochlear implant technology can be improved from the perspective of music perception and cognition. Specifically, this study aimed to discover issues concerning CI likes and dislikes of six compositions and document similarities and differences in the concert experience of different groups of listeners.

Method

3.1 Design rationale, material and participants

The present research took part in the context of a specially organized concert (two performances with different audiences on the same day) consisting of works developed and written by new music composers to be performed for a CI audience. The participants had already completed an anonymous self-report questionnaire

during the concert (Au et al., 2012), and the present study was designed to counter some of the limitations of those techniques—namely to allow people to discuss among themselves what their perspectives were of the concert. In our design, the concert was used as a provocateur to initiate discussion about the issues that were pertinent in music enjoyment for CIs. Furthermore, since the concert audience consisted of a mixture of hearing impaired and normally-hearing (NH) listeners, responses from NH participants and others with varying degrees of hearing assistance could be used to compare with bilateral CI responses.

For each concert, three focus groups were formed with 5 to 7 participants per group. Two of the researchers (authors ES and CJS) and an external researcher, Dr. Tom Francart acted as moderators. None of the three group moderators were affiliated with the concert organization, the performers or the commissioned composers. One of the focus groups consisted of CIs only (bilateral), another of NHs only, and a third that was a mixture of either (1) CI, bimodal CI with HA, and HA (hearing-aid user) and (2) HA and NH (without cochlear implant). These combinations of all, some and no CIs were considered worthwhile for eliciting varieties of social contexts. When reporting results, however, data from individual responses are attached to the type of hearing correction, rather than the nature of the group. For example, a response from an individual CI in a mixed grouped is treated as the CI response of the individual, rather than a response representing the group as a whole. Because the concert was performed twice, and therefore the focus group sessions were held twice as well, data from six groups were available for analysis.

Due to the extremely limited time available, little background information was collected from the participants during the focus group sessions. When possible, additional information was obtained from completed ethics forms. A summary of the available relevant details for each participant is provided in Table 1. Out of 32 participants, 18 were female. Only two ages were recorded for the normal-hearing participants (67 and 20 years). In the two hearing-impaired groups, ages ranged from 16–82 (mean 55.4 years, standard deviation 18.2 years).

3.2 Procedures

Prior to the concert, prospective participants were invited to participate in a focus group that would take place at the end of the concert. We were seeking three groups

of focus group participants per concert, one consisting of normal hearing audience members, another of cochlear implantees and a third of a mixed group. Participants were assigned to the groups in the order in which invitations were accepted. Those participants who accepted were ushered to a large room at the base of the auditorium (near the Fairfax Studio in the Arts Centre Melbourne), where they sat in one of three well-separated sections of the room. They read and completed ethics declarations. An audio (and where possible, video) recording was made of the sessions. Video recordings aided in the identification of speakers during the transcription phase of the study and were destroyed after the transcription was completed.

Each session took a maximum of 15 min. The moderator welcomed the participants, and started the session by asking the group what they thought of the concert, if there were any pieces that were preferred, and to explain why they liked those pieces (if any). The moderator's role was to keep responses flowing, on task and to encompass all members, with minimal disruption to within-group, on-task discussion. If the conversation did not naturally move in that direction, the moderator would find a point approximately half way through the session to ask the group members about the pieces they did not like, and to explain why. The brief used by the moderator is shown in Figure 1.

3.3 Concert details

The concert consisted of six pieces of around 10 min length each, composed by six Australian new-music composers: Robin Fox, Rohan Drape, Ben Harper, Natasha Anderson, James Rushford, and Eugene Ughetti. The composers developed their pieces in consultation with scientists and the Bionics Institute in Melbourne, as well as working with four adult cochlear implant recipients with whom the composers could test compositional ideas. The composers could also use multimedia approaches, some choosing to access software which could reproduce and sonify the output of a cochlear implant sound processor. The works were performed at the Fairfax Studio at the Arts Centre Melbourne. The finalized six works were a mixture of live instruments played on stage and pre-recorded instrumental, vocal, or synthesized audio. Two-minute extracts from each of the six pieces can be found in the Supplementary Material for this article. The abbreviated notes for the six pieces that follow are taken from Au et al. (2012, 338–339):

Piece 1—Variations: The composer explored the contours and intervals created by using dynamics, duration, pitch, and repeated variations on a simple theme. Instrumentation: pre-recorded piano with live clarinet, viola, and cello. (see Supplementary Material – Piece 1)

Piece 2—Percussion with vibraphone: Percussion instruments were chosen based on feedback that CIs found them to be easy instruments to distinguish. A bowed vibraphone was used to add a controlled pulse to the sound produced. Synthesizer bursts designed to rapidly stimulate sequential electrodes also were used to create sound textures that could potentially be interpreted by the CI. The live performance enabled listeners to make use of visual cues provided by the movements of the performers while pre-recorded material was used to create spatialized sound from the 11.1-channel audio diffusion system in the auditorium. Instrumentation: live bongo and conga drums, shaker, and bowed vibraphone, with spatialized diffusion of pre-recorded piano, cello, and synthesized sound. (see Supplementary Material – Piece 2)

Piece 3—Spoken word: Based on the well established speech processing capabilities of the cochlear implant, this piece primarily used fragments of spoken phrases superimposed over short electronic melodies that emulated the rhythm and intonation of the speech fragments. Instrumentation: pre-recorded voice with spatially diffused synthesized keyboard/vibraphone using a tuning system based on cochlear implant sound-processor channel frequencies. (see Supplementary Material – Piece 3)

Piece 4—Pitch: This piece involved multiple lines of melody in a trio for cello, viola, and tape recorder. Extended technique (when the performer plays the instrument in an unconventional way, such as slapping the body of the cello) and preparation (such as the attachment of adhesive to strings) of the live instruments introduced differences in the instruments' timbre and attack, sustain and release times. Instrumentation: live cello and viola, pre-recorded processed tape recordings of cello and viola. (see Supplementary Material – Piece 4)

Piece 5—Electronic: Pulse, rhythm, and tone were separately explored in this three-part piece. In 'study 1', spatialization of a constant pulse was achieved via the 11.1-channel diffusion sound system. In 'study 2', rhythmic patterns were created using complex tones with fundamental frequencies set at the centre frequencies of the 22 filters present in a cochlear implant (250, 375, 500, 625, 750, 872, 1000, 1125, 1250,

1437, 1687, 1937, 2187, 2500, 2875, 3312, 3812, 4375, 5000, 5687, 6500, and 7438 Hz). In ‘study 3’, chords were generated by gradually introducing single pure tones through different channels of the 11.1-channel sound system. Finally, screens with colour fields synchronized to the audio signal were used throughout the piece to provide congruent audiovisual cues. (see Supplementary Material – Piece 5)
Piece 6—Percussion: Male voice and a wide variety of tuned and untuned percussion instruments were exclusively used in this piece, taking advantage of the implant’s ability to convey amplitude envelope fluctuations. Familiar rhythms were overlaid and varied. Instrumentation: large percussion ensemble with three players. (see Supplementary Material – Piece 6)

4 Results and discussion

4.1 Overview

Audio/Video recordings were transcribed professionally across each of the six focus groups. 888 lines of text (hence ‘data units’ after Saldana, 2009; Stemler, 2001) were coded over three stages. Focus group transcripts were analysed as individual responses grouped by type of hearing assistance. While some researchers regard this as an unconventional way of using focus group data—where the group should emerge with a set of more-or-less agreed perspectives—others argue for more flexibility in using focus group data, and to base the analysis on research needs (Barbour & Kitzinger, 1999; Bloor, Thomas, Robson, & Frankland, 2001; Johnson & Christensen, 2012; Krueger & Casey, 2009; Morgan, 1995). Our approach was intended to promote discussion in a group with the aim of finding reasons for liking/disliking music in the concert; and our interest was in the views of individuals within this context and in general. Repeating a focus group with different people but similar impairments (e.g. CI) alleviated the presence of systematic, idiosyncratic dominant voices in one of the groups (see, e.g. Erlandson, Harris, Skipper, & Allen, 1993; Johnson & Christensen, 2012, p. 205; Morgan, 1995; Oates, 2000, p. 193). Moderators reported occasional dominating voices, but that overall, all participants made some contributions, and this was confirmed by inspection of the transcribed text: The number of per-participant data unit contributions ranged from the two lowest of 4 (two NH participants) and 7 (one CI and one NH participant) to an upper count of 51 and 52 units (each by different CI participants). One participant matched the median count of 17 (a CI participant), with each of the hearing

assistance types represented and distributed fairly evenly across this range. The analysis was performed in three stages as outlined below.

4.2 Stage 1. Data preparation, emergence and refinement of themes

As per the approach recommended by Krippendorff (2004) each participant's spoken data unit was initially labelled (1) exhaustively (minimizing amount of data left uncoded), (2) as mutually exclusively as possible (minimal overlap in meaning of labels), and (3) inductively (that is, allowing labels to emerge from the data, as interpreted by the researchers: Elo & Kyngäs, 2008). These labels were checked and then reduced to a list of 16 emergent themes, which were then revised to 12 credible, and viable emergent themes that relate to the research aims (Graneheim & Lundman, 2004) by authors CJS and ES. It is important to note that the four omitted themes were not removed because of their irrelevance, but because they occurred infrequently, making comparisons among groups unreliable. For details and examples of the omitted themes see Appendix. The remaining 12 themes are described in Table 2, and were either (1) further grouped into subcategories, (2) deleted from further analysis, or (3) left intact in Stage 3, with justifications for each as described in the following analyses, grouped initially by subcategory.

4.3 Stage 2: Reliability and valence coding of emergent themes and subcategories

After the identification of the 12 themes and the removal of the unused data units identified in Stage 1, a subset of data units were selected for reliability checking and more detailed analysis. Those units consisted of a balanced sampling from each of the six focus groups. This subset of the focus group transcriptions were then coded again by two independent coders who had no direct connection with the project, but were experienced at coding qualitative data. Between the two coders all data units were coded a second time (at least 146 lines coded by each). This allowed direct comparison with the Stage 1 coding of the 12 themes. The comparison of the second stage coding and the initial coding produced a Cohen's Kappa reliability of 0.787. The non-matching codings were either corrected (if due to an obvious error) or deleted from further analysis, leaving a total of 291 data units for further analysis. In addition, 'valence' analysis was performed, where each data unit was classified as being positive, negative or neutral, with regard to the evaluation made about a listening experience. Valence coding was based on the evaluative content

magnitude code proposed by Saldana (2009) and directionality coding used by Hesse-Biber, Dupuis and Kinder (1991). The results of the Stage 2 themes are now reported, but for the sake of expedience are grouped into the sub-categories to be discussed in the Stage 3 results (Table 2). The number of occurrences of each theme by hearing impairment type is reported in Table 3.

4.3.1 Features/elements of the music subcategory

The 'features/elements of the music' subcategory included any mention of musical or music related aspects made during the focus group meetings and was identified in 111 data units. The data units related to the theme of Elements of the Music (82 occurrences, CI 29, NH 34),[1] such as '*It had some sort of beat going to it*' (GCI1-5-CI),[2] the theme of Aesthetic/Musical Aspects (12,6,1: for example, GHA1-2-HA: '*I thought the music was too experimental, that you would need too much musical experience in order to appreciate it, and for people with hearing impairment, they want popular music.*'), the theme of Performer Aspects (8,1,4), such as GNH1-3-NH who was justifying enjoyment of the last piece: '*The musicians—it was more interactive amongst the musicians, and I could relate to it, I guess, a little bit more*', and the theme Repetition and Other Structural Aspects of the Music (11,5,6). Five data units of this theme indicated lack of satisfaction about the works in question for both CI and NH participants, such as:

GCI1-5-CI: *But I sort of felt it was going to lead to something, but it kept sort of staying there like a stuck record, and I thought, 'This is—this could produce—this could turn into something with a—' but it sort of stuck there going 'eeeeeeee', and as I said, it flat-lined for me.*

and

GMIX1-6-NH: *There was too much of the same tone repeated and repeated, and I felt like walking out.*

4.3.2 Tactile/visual subcategory

The majority of tactile/visual references were made to the Visual Aspects theme of the performances (59,28,11), compared with Tactile (5,0,0). Visual references were both negative (GCI2-1-CI: I prefer without the visual bits) and positive (GMIX1-3-CI: *Well I loved the last one, and probably the second last one too, because of the*

visuals; and GCI2-6-CI: *But I found the ones with the drummer most delightfully theatrical*). Tactile references were made only by HA users, such as GCI2-4-CI-HA: *But the cello was the interesting thing, feeling it in the soles of my feet, and feeling it in my body.*

4.3.3 Extra-musical subcategory

The extramusical subcategory grouped together themes that were not intrinsic to the music nor the musical spectacle, but rather thoughts and images evoked by the music, specifically the themes of Imaginative Aspects (3,1,1) and Memories Evoked (7,0,2). The small number of data units fitting these themes demonstrates that they were not necessarily a key part of the listening experience, but they do indicate that CIs, HAs and NHs experienced them. For the Imaginative aspects theme we had:

GCI2-3-CI: *I just closed my eyes, and just assume that you're seeing instruments.*

GHA1-3-HA: *But definitely the last two I kind of got lost in the music.*

GMIX1-1-NH: *That was very hypnotic, the last piece too, that was very interesting, but for me the Ben Harper Piece was quite interesting.*

Although the contribution of the Memories Evoked theme may seem trivial since no CI or NH data units were explicitly identified with this theme, a powerful response came from an HA who recounted her husband's post cochlear implant experience of music:

GHA1-4-HA: *Well, my husband has the cochlear implant, and he used to love classical music.* [1] *Cried at all the operas, cried at the violin concertos, etcetera. And now, I don't play music at home because he'll cry anyway now because it's so sad he can't hear it anymore, and I think this is very commendable, that you're trying to do something—well, he's quite an older man—but for younger people particularly, if they can get some enjoyment through having the music tuned into their implant, I think it's a wonderful thing you're doing.* [2]

Although GHA1-4-HA was recalling strong memories, the second data unit of the excerpt (numbers in square brackets), which was a continuation of the first, was also coded as the Affect/Emotion theme. Note that this second data unit also contained

the deleted theme of ‘wishes for the future’, but here the surviving coding is the one that was used.

The remaining four themes (Table 2) are reported separately.

4.3.4 The ear-interface theme and the spatialization aspects theme

Two themes emerged that demonstrated new insights into how CIs deal with music. First, spatial position of sounds emerged as being important for some CIs:

GMIX1-3-CI: *And also at the start of that piece, being bilateral, I had different sounds coming through each side, so I was really enjoying that, sitting back, taking it all in, getting that directional sound.*

In all there were 14 data units that referred to spatial issues (14,4,3), though of course the participants required some form of hearing (organic or assisted) in both ears. And it was the (bilateral) HAs and (bimodal) CI-HAs in the mixed groups who noticed these most frequently (seven data units).

Ear-interface themes emerged for the hearing assisted groups only (22,12,0). However, it is another theme that rarely appears in the literature. The theme recounts how hearing assisted individuals experiment with musical sounds to help them optimize the experience. Importantly(see Section 5), many HA and bilateral participants switched their hearing aids off or removed them as a way of experimenting with or improving the experience.

GCI2-4-CI-HA: *And during the evening, I was turning my hearing aid on and off, just testing the difference, and I found that I was enjoying the music much more if I had my hearing aid off.* GCI1-5-CI: *I’ve got the—I’ve got the latest processor, whether that’s good or bad. But to me—I mean, I’m still sort of in the Dalek stage, everything sounds a bit robotic still. But still, yeah, music is—I took—I actually took it off.*

However, there was some confirmation that it takes time to become accustomed to new hearing assistance devices:

GCI1-3-CI: *But I’ve found that—I’ve had it for five years now, and every year it has got better and better.*

4.3.5 Ordinal aspects theme

Eighteen data units were identified as containing ordinal information (20,6,7). The first, second, third, fifth (second last) and sixth (last) pieces each were explicitly mentioned by ordinal position, with one additional reference to a piece ‘close to the front’ (GCI2-6-CI). Both the CI and NH participants (four data units each) agreed that the last piece was the most enjoyable, with the HA participants (two data units) liking the last two pieces.

The ordinal aspects theme was identified as having potential to explain possible biases towards pieces in particular ordinal positions. For example, some research on product and music choice suggests preference for the first in a list of items (Carney & Banaji, 2012; Pandelaere, Millet, & Van den Bergh, 2010). The present analysis has identified that the last piece was the most enjoyed across groups and individuals in terms of counts, and is consistent with an earlier study (Au et al., 2012). We therefore had no further reason to think that this choice was a psychological artifact, and the Ordinal Aspects theme was deleted from further analysis.

4.3.6 Emotion/Affect theme

The Emotion/Affect theme was identified frequently but was also frequently associated with other themes. Indeed, on many occasions the Emotion/Affect theme was merely colouring another theme. The moderator’s were briefed to ask which pieces group members liked/disliked, and why. This theme mostly coded the nature of the liking/disliking (e.g. hated the piece, made me cry, was thrilling). The purpose of the focus group was to uncover why these evaluations were made. Therefore, when a reason (another theme, usually) was reported, the Emotion/Affect label could be abstracted. As a result, there remained 20 (20,2,14) data units that were coded as this theme, such as:

GMIX1-4-CI: *Some of it was almost like medication, you could listen to it, and it just calms you down and you could go to sleep.*

and

GNH2-3-NH: *I think it got a bit boring too, though.*

It became apparent that nearly all data units consisting of the theme Emotion/Affect could be coded separately according to valence, that is, in terms of how another

theme is evaluate, or simply an evaluation without reason (Charland, 2005; Colombetti, 2005; Schubert, 2012). For example, GMIX1-4-CI, above, can be coded as positive valence, and GNH2-3-NH as negative valence. Subsequently, in the next stage of coding, the Emotion/Affect theme was deleted and the data units recoded into a separate valence classification. Those data units with unclear or no valence were classified into a third option, as 'neutral' valence.

4.3.7 Stage 3: Distinguishing CI, NH and other hearing type experiences

In Stage 3, the 12 themes were reduced to five broad sub-categories with the aim of grouping themes of similar meaning, and removing themes of limited value. This facilitated statistical analysis, and allowed broader conclusions and confirmation of observed trends. Content analysis was then performed of the most frequently occurring subcategory. The second stage of analysis provided insights regarding the range of experiences the participants reported, and the significance of the themes (based frequency of occurrence). The third and final stage of analysis aimed to identify which experiences were reported positively or negatively, using a statistical approach. To apply statistical analyses with subcategories, groups of responses to be compared need to be large enough (a general rule of thumb is greater than five—so five data units or more, see Mantel & Fleiss, 1980).

To examine whether CI participants had an overall positive experience during the concert, two comparisons were made. First, each of the data units were coded according to whether a comment about a piece was neutral, positive or negative ('valence'). This subsumed the now deleted Emotion/Affect theme. For example, the following was coded as within the theme 'Ear-interface' related, and as positive valence:

4-CI: *I did, I actually had a neck piece, and I switched it off and I didn't use, because acoustically it was fantastic, so I didn't need it.*

Table 4 shows the results of two statistical analyses for the three subcategories (the source of the subcategories are shown in Table 2). The first statistical analysis tested whether the count of a subcategory was different for CIs than for NHs. Of all the comparisons, only the Tactile/visual subcategory was significantly more frequent for the CIs than NHs (χ^2 (1, $N = 39$) = 16.01, $p < 0.001$). The second statistical

analysis compared the ratio of positive to negative valence counts for the CI group with the same ratio for the NH group, to test whether the ratio of positive to negative valences was different between CIs and NHs. In the case of the Features/elements of the music subcategory, 16 CI responses were coded as negative valence (e.g. GMIX1-4-CI: *It wasn't melodious, it was distorted! To me I like classical music, so nowadays I've got the implant things sound distorted, but that was really distorted—bad.*) and 22 as positive (e.g. GCI2-1-CI: *I found with all of them that I could hear individual instruments, which is something I haven't been able to do for years.*). However, statistically the ratio of positive to negative valence counts was the same as for the NHs (20 negative, 29 positive valence data units), according to the chi-square test (χ^2 (1, $N = 38$) = 0.03, $p = 0.872$). The valence comparison for the other two categories were considered unreliable because the cell sizes were small (always less than 5 for NHs).

Since Features/elements of the music was the most frequently reported subcategory, and since certain musical features are reported in the literature as having differential efficacy for CIs from NHs, a content analysis was performed. The analysis included sorting the items by valence, so that meaningful comparison was possible between CIs and NHs (non-bilateral CIs were omitted from this analysis due to small number of Features/elements identified).

The top half of Table 5 summarizes the number of times a particular musical instrument was mentioned. For example, the synthesizer was mentioned with a positive valence by one CI:

GCI1-2-CI: *I particularly liked the percussion, ...And I liked the synthesized—I think it was the third—piece, the synthesizer ...*

and by a NH, but with negative valence:

GMIX1-6-NH: *I didn't like the first one, this had the cello, violin, clarinet, synthesizer.*

Most striking in this analysis is that percussion instruments were mentioned most frequently, and that they were always mentioned with positive valence. Furthermore, CIs made these positive mentions twice as frequently as NHs (10 mentions versus 5).

The bottom half of Table 5 shows the tally of musical features.

Pitch/melody/harmony related terms were identified in CI responses with negative valence, but interestingly the same applied to NHs. Furthermore, rhythm/beat related

terms were mentioned more frequently than other musical features for both CIs (3) and NHs (5).

5 General discussion

Jump to section

Among the more poignant comments that came from the focus groups was one by a CI who was a passionate music lover before acquiring a cochlear implant. At one point in the meeting he indicated:
GCI2-6-CI: *frustration at not being able to hear music with a CI. Mozart sounded like 'pots and pans falling down the stairs' after my CI.*

It is responses like this that highlight the challenges faced by CIs, and how researchers must grapple with these limitations and seek other ways of finding, if not improving, musical experiences for CIs. Our approach is a new one because it accepts the difficulties that people like GCI2-6-CI experience by the possibility of never being able to have the powerful, joyous experiences of Mozart he once had. Rather, our work capitalizes on the idea that development of familiarity ('from scratch' if you like) to new musical signals will be a beginning to a new way for some CIs to begin to enjoy music again.

The data from the focus groups provide arresting evidence that supports our 'third branch' approach: employing the skills of new-music composers who have the sensitivity and capacity to accommodate the limitations of cochlear implants, bringing normal hearing (unfamiliar with new music and other experimental forms) and listeners with cochlear implants somewhat closer to an equal footing. It is conceivable that NH members of the focus group found the concert unfamiliar in a

way that music had become unfamiliar to CIs. And our main findings were that, with these ‘equalisers’ there was little difference in the broad perspectives of the two groups about the musical items. Both liked the rhythmic aspects, both found some of the high-pitched sounds and dissonances distressing, and in some ways CIs (including non-bilateral hearing assisted users) had some additional resources—such as turning their devices on or off to try to optimize their experiences. As past research suggests (Gfeller, Knutson, Woodworth, Witt, & DeBus, 1998; Looi, McDermott, McKay, & Hickson, 2008; McDermott, 2004), CIs enjoyed the rhythmic pieces but in addition, percussion instruments were explicitly identified as enjoyable instruments to listen to.

The value of visual interest was reported by both groups, though more frequently by CIs, consistent with pioneering work of Gfeller and colleagues who trained and encouraged CIs to complement listening with visual stimulation, such as watching the singer (Gfeller, 2012; Gfeller, Christ et al., 2000). In addition to ear-interface settings, another theme that emerged, which has received little attention in past research, is spatialization. The bilateral CI focus groups (as well as the CI-HA participants) were sensitive to and appreciative of spatial effects that were allowed by the 11.1-channel audio diffusion surround sound system and placement of musicians in the auditorium. Like rhythmic elements, spatialization might be an important parameter that CIs could use more, and thus composers and music producers could further recruit, to facilitate greater enjoyment of music.

The present study has therefore identified possible new directions CI music appreciation could take in the future. However, also important is whether, through continued exposure, these participants, and their NH counterparts, may learn to develop an appreciation, and perhaps a love, of the newly composed music, as they develop and revisit new mental representations formed by these pieces. Such an approach capitalizes on the documented significance of familiarity of music in its enjoyment, and associated cognitive models of music processing (Schubert, 2012).

6 Conclusions

Jump to section

The present investigation into appreciation of music by cochlear implantees used a focus group method to try to identify positive and negative experiences in music appreciation, as stimulated by a concert held just before the focus group meeting. The concert consisted of six specially commissioned works where new-music composers worked closely with hearing scientists and people who had cochlear implants. The concert was repeated, and the focus group sessions were repeated. Furthermore, normal hearing and other (non-bilateral) hearing assisted individuals who attended the concert also formed focus groups to allow comparison of experiences.

Several issues thought to be of great significance to CIs in enhancing their musical experiences were also reported by the NH listeners. The most common themes arising were concerned with rhythm, visualization and spatialization. It is only in the last few years that the significance of the visual modality upon music perception and appreciation has received systematic research attention in NH listeners (Behne & Wöllner, 2011; Broughton, Stevens, & Malloch, 2009; Marin, Gingras, & Bhattacharya, 2012; Marozeau, Innes-Brown, Grayden, Burkitt, & Blamey, 2010; Petrini, Crabbe, Sheridan, & Pollick, 2011; Vines, Krumhansl, Wanderley, & Levitin, 2006) and for CIs (Innes-Brown, Marozeau, & Blamey, 2011). This oversight most likely indicates that NHs take the visual mode for granted, whereas CIs become more attuned to that mode, which transmits information in a way that follows normally from pre-implant memories.

Conversely, the importance of rhythm may come to the fore for NH participants when there is little else those individuals have to connect with in the new-music experiences which are also relatively novel to them—new music tends to focus on timbral palettes rather than conventional rules of harmony and voice-leading. The aesthetic affect of using space in music is an area that has received little attention for both CI and NH listeners. Only recently has the spatial perception in music become

an area of interest in music psychology, and it is still largely the domain of new-music, experimental and acousmatic musics (Kendall, 2010; Stefani & Lauke, 2010).

The main conclusion we draw from our results is that familiarity may be the main, underlying factor that affects music appreciation in CIs. By losing access to the aural *stimulation* of much, if not all, pre-implant, musical memories, CIs are no longer able to derive musical pleasure in the way their normal hearing counterparts can. The idea that stimulation leads to pleasure is based on the theory that mental activation in an aesthetic (music) context is in and of itself pleasurable (Schubert, 2009–2010). But if we deplete the normal hearing listener's access to musical memories, through exposure to new music, we find that the overall differences in experience between CIs and NHs are considerably mitigated: both groups enjoy the music in a much more similar way. Further research will confirm this conclusion, for example through longitudinal studies where CIs and NHs continue to be exposed to the new music, allowing new musical memories to be formed, and later (eventually) enjoyed (Schubert, 2010; Schubert, Hargreaves & North, 2014). Thus, we claim to have a response to the conundrum posed by Gfeller where she stated that '[i]t is possible that successful implant users find music listening more enjoyable, and therefore spend more time engaged in music listening. It also is plausible that more time spent in music listening can contribute to improved musical perception' (Gfeller et al., 1997, p. 253). Encouraging new, rather than just focusing on reviving pre-implant, musical experiences may provide a promising avenue for understanding, diverting and perhaps even mitigating the problem of '*Mozart sounding like pots and pans falling down the stairs*'.

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Appendix

Omitted themes

The four omitted themes each provided potentially important interpretations, but were given no further attention in this analysis. The four deleted themes were (1) 'Related to cognitive and metacognitive perspectives'—with only two data units identified, one being:

GHA1-4-HA: *Well, I think it's a good idea for us to have an open mind about this sort of thing, not just go on the expectation of listening to some waltzes or something like that, and I think if you leave your mind open, which I tried to do, I found that that helps to enjoy that sort of music as well*

(2) 'Organizational aspects'—'GNH1-3-NH: *I would have preferred if the pieces were introduced.*' (with four other data units identified matching this theme)—(3) 'Wishes for the future' of which three data units were identified, including: 'GCI2-5-CI: *I came away thinking, I really hope that good music appreciation programs will be developed for processors, so we can really enjoy music.*', and one unit was coded as (4) 'Sympathy for hearing impaired person(s)'—'GNH2-3-NH: *We're composing work for them to enjoy, or whatever, for the "first" time*'.

Notes

a Multiple terms in square brackets for an item could have occurred within one count. For example, although only two counts were made of this term, more examples are reported because participants mentioned more than one term related to the item in the same data unit: 'GCI2-5-CI: audiovisual pieces clangy and jarring and discordant'. As this quote was a single data unit, it was coded as a 'dissonance' item only once.

b There was no conventional clavichord used in the concert.

1 The triad of numbers that is shown in subsequent parentheticals corresponds to the number of data units in total, the number of CI data units, and the number of NH data units respectively for the theme being reported. The difference between the CI plus NH tallies (the last two numbers) and the Total (the first number) is the tally of the other data units (HA), and is not shown in the parenthesis.

2 The code for the identity of the individual behind the data unit reported is Group type Group number—Within group participant number—nature of hearing assistance. When a group contains different kinds of hearing assistance, it is referred to as GMIX. As an example, in the quote shown GMIX1-4-HA indicated a participant in one of the mixed focus groups that took place after the first concert (groups 1, 2 and 3), hence GMIX1 (G[roup] 'MIX' number 1), the person speaking being participant 4 in that group who used a hearing aid only for hearing assistance (4-HA). The other focus groups were one of the two Cochlear Implant groups (CI), or one of the two Normal Hearing (NH) groups (see Table 1). Individuals were coded separately in the last characters of the code to indicate the nature of the group member to her/his constituents.

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Rohan Drape – Another in Another Dark, Natasha Anderson Study for the Bionic Ear #1, Ben Harper – This is all I need, James Rushford – Tussilage, Robin Fox – Three Studies for the Bionic Ear and Eugene Ughetti – Syncretism A.

The excerpts are from ABC classic FM's recording of the live performance of the Interior Design, http://musicalbionics.wordpress.com/2013/10/17/interior-design-listen-to-the-abc-podcasts-of-the-concert/. The pieces performed live or with live accompaniment were performed by Speak Percussion and Golden Fur.

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Table 1

	ID	Group	Age	Gender	Hearing (L/R)	Learnt instrument?	Current musical ability
1		GNH1	–	Female	NH	No	None
2		GNH1	–	Female	NH	–	–
3		GNH1	–	Female	NH	–	–
4		GNH1	67	Male	NH	Yes	None
5		GNH1	–	Female	NH	–	–

ID	Group	Age	Gender	Hearing (L/R)	Learnt instrument?	Current musical ability
6	GNH1	20	Female	NH	Yes	Professional
7	GNH2	–	Female	NH	–	–
8	GNH2	–	Female	NH	–	–
9	GNH2	–	Male	NH	–	–
10	GNH2	–	Male	NH	–	–
11	GNH2	51	Female	NH	No	None
12	GMIX1	32	Female	HA/CI	No	–
13	GMIX1	55	Female	HA/CI	No	–
14	GMIX1	68	Male	HA/CI	Yes	None
15	GMIX1	34	Male	NH	Yes	None
16	GMIX1	33	Female	NH	Yes	None
17	GHA1	54	Male	HA/HA	Yes	None
18	GHA1	70	Female	HA/HA	No	–
19	GHA1	40	Male	HA/HA	Yes	Amateur
20	GHA1	–	Female	HA/HA	Yes	–
21	GCI1	82	Female	CI/CI	Yes	Amateur
22	GCI1	60	Female	ND/CI	Yes	None
23	GCI1	62	Male	CI/CI	Yes	None
24	GCI1	76	Female	HA/CI	–	–
25	GCI1	60	Male	NH	No	–
26	GCI1	75	Male	NH	–	–
27	GCI1	16	Male	ND/CI	No	–
28	GCI2	73	Male	CI/ND	Yes	None
29	GCI2	77	Female	HA/CI	Yes	Amateur
30	GCI2	55	Male	CI/ND	Yes	None
31	GCI2	60	Male	CI/ND	Yes	Amateur
32	GCI2	31	Female	CI/CI	Yes	Amateur

Note: CI: cochlear implant. HA: hearing aid. NH: normally-hearing. ND: no device. '–' indicates missing data. Final numeral after Group code indicates after which of the concerts the focus group was held.

Figure 1

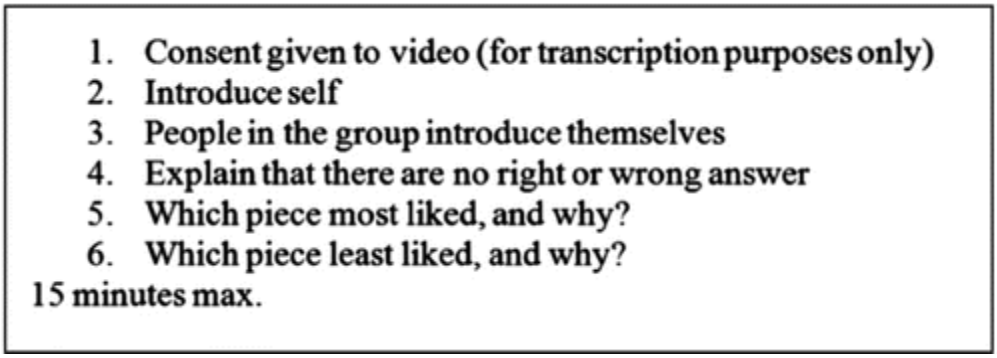

Table 2. Twelve initial themes identified during coding and their translation into five categories, including examples.

Stage 1/2: 12 themes	**Examples of theme**	**Notes and Memos for Stage 2 to Stage 3 analysis transition**	**Stage 3: 5 sub-categories**
1) affect/emotion	tedious/meditative	These could be 'valence' outcomes/judgements/evaluations. E.g. 'tedious' (negative valence). So next phase of coding decisions should favour another label where possible (e.g. repetition), with valence coded separately.	Deleted
2) ordinal aspects	first, last, primacy, recency	Participants used order terms as a shorthand to the piece in question.	Deleted
3) imaginative aspects	hypnotic	References to non-musical thoughts	Extra-musical (themes 3

Table 2. Twelve initial themes identified during coding and their translation into five categories, including examples.

Stage 1/2: 12 themes	**Examples of theme**	**Notes and Memos for Stage 2 to Stage 3 analysis transition**	**Stage 3: 5 sub-categories**
		triggered by the music. Could link with ‘memory’ code.	and 4)
4) memory evoked	reminder of something	Link to imagination	
5) aesthetic/musical aspects	low level ‘sounds’ vs high level ‘musical’	Link to musical features.	Features/elements of the music (themes 5 to 8)
6) features/elements of the music	frequency (low/high); pitch/low/high; amplification,loud soft; rhythm, beat;harmony; instruments,percussion/cello/drums...	Possible links to repetition and structural aspects, and performer features.	
7) performer features	virtuosity	Could be integrated/related with musical features/visual aspects.	
8) repetition and other structural aspects of the music	repetition	Could be integrated with musical features.	
9) ear-interface related	device turning on/off/adjusting/removing	This code is clearly peculiar to participants	Ear-interface (retained)

Table 2. Twelve initial themes identified during coding and their translation into five categories, including examples.

Stage 1/2: 12 themes	**Examples of theme**	**Notes and Memos for Stage 2 to Stage 3 analysis transition**	**Stage 3: 5 sub-categories**
		with hearing correction devices—cochlear implants and hearing aids.	
10) spatializationaspects	left, right, surrounded	Could be integrated with musical features, but spatialization emerges as a code of some significance to CI participants.	Spatialization (retained)
11) tactile aspects	could feel through my feet	Extramusical aspect, but is important in distinguishing CI and NH groups.	Tactile/Visual (themes 11 and 12)
12) visual aspects	could not see/could see/impressive visual/lighting	Extramusical aspect, but is important in distinguishing CI and NH groups.	

Table 3. Theme counts by hearing impairment type.

Theme	**Total**	**CI**	**NH**	**HA**
Elements of the Music	82	29	34	19
Aesthetic/Musical Aspects	12	6	1	5
Performer Aspects	8	1	4	3
Repetition	11	5	6	0
sum	**123**	**41**	**45**	**27**

Table 3. Theme counts by hearing impairment type.

Theme	**Total**	**CI**	**NH**	**HA**
Visual	59	28	11	20
Tactile	5	0	0	5
sum	**64**	**28**	**11**	**25**
Imaginative Aspects	3	1	1	1
Memories Evoked	7	0	2	5
sum	**10**	**1**	**3**	**6**
Spatial	14	4	3	7
Ear-interface	22	12	0	10
ordinal information	20	6	7	7
sum	**56**	**22**	**10**	**24**
Emotion/Affect	20	2	14	4

Table 4. Count of subcategories for CI and NH by valence

Subcategory		
Valence	**CI**	**NH**
Features/elements of the music (Total)	41	51
–	16	20
+	22	29
Neutral	3	2
Tactile/visual (Total)	28 [a]	11 [a]
–	10	3
+	9	4
Neutral	9	4
Extra-musical (Total)	1	1
–	0	0

Table 3. Theme counts by hearing impairment type.

Theme	Total	CI	NH	HA
+			0	0
Neutral			1	1

Note: Like superscript denotes significant difference according to chi-square tests at $p = 0.01$. All other chi-square comparisons were not significant at $p = 0.05$. See text for further details. + denotes positive valence. –denotes negative valence.

Table 5. Content analysis of Musical features/elements for CIs and NHs by valence.

	CI	NH
VALENCE INSTRUMENTS (TIMBRE)		
Negative	violin (2); cello (2); clarinet (2)	violin; cello (distorted); clarinet; synthesizer
Positive	percussion [incl. drum, bongo] (10); synthesizer	viola; percussion (5); voice
Neutral	percussion etc. (4); guitar; clavichord[b]	strings (2); percussion (2)
MUSICAL FEATURES		
Negative	dissonance [clangy, jarring, discordant, shrill, distorted, shrill][a] (2); melody [absent]; pitch [high, ear splitting]; Frequency/pitch [low] (2); rhythm	pitch [high] (2); rhythm [absent]; dissonance [discordant, chaotic, noise] (3)
Positive	rhythm/beat (3); melody [absent]; pitch [low frequency]	harmony; rhythm (5); dynamics [loud]; pitch
Neutral	melody (2); Frequency/pitch [high]	melody; rhythm

a Multiple terms in square brackets for an item could have occurred within one count. For example, although only two counts were made of this term, more examples are reported because participants mentioned more than one term related to the item in the same data unit: ‘GCI2-5-CI: audiovisual pieces clangy and jarring and

discordant’. As this quote was a single data unit, it was coded as a ‘dissonance’ item only once.

b There was no conventional clavichord used in the concert.

Note. A number in parentheses after an item indicates that the item was identified in that many data units (greater than one). Items are separated by semicolons. Instruments are listed in instrument family groups for ease of comparison.