Improving music appreciation for the world's more than 700,000 cochlear implant users

June 2 2022, by Geoffrey Waring

Credit: Kristin Brokaw

Sound serves a variety of purposes in our lives. You hear a car's tires screech and you jump back, preserving your life. Someone calls your name from across the room and you turn to see what they want. Speech is one of the primary forms of communication, helping people connect, share their thoughts, give instructions, receive advice and comfort.

And then there's music. Twelve simple tones, played on a variety of instruments and in seemingly endless combinations, music may be the ultimate form of the whole being greater than the sum of its parts. Music pumps us up at the gym, it helps us heal in times of heartbreak or grief. It brings people together, it accompanies us in solitude.

No one understands the importance of music more than Dr. Raymond Goldsworthy, head of the Bionic Ear Lab in the USC Caruso Department of Otolaryngology-Head and Neck Surgery. Dr. Goldsworthy lost his hearing at the age of thirteen, just as he was beginning to learn the drums. Like every teenager, he was just beginning his journey into the seemingly limitless world of music, when a bout with spinal meningitis and the ensuing treatment damaged his hearing.

"There is never a good time to lose your hearing, but what was particularly challenging for me at that age was that my friends were discovering new music," Dr. Goldsworthy remembers. "It hurt that I could not turn to music for comfort during that time."

He received a cochlear implant, then a relatively new technology that has since become a life-changing device for hundreds of thousands of hard-of-hearing people. Cochlear implants are sound processors that sit behind the ear, catching sound and transmitting it via electrodes that stimulate the auditory nerve. The result is an approximation of hearing that, while perhaps less precise than an average person's, can help restore a remarkable degree of ability when hearing loss has progressed to the point that a hearing aid is no longer useful.

And, as Dr. Goldsworthy and his researchers at the Bionic Ear Lab have shown, technology can always be improved.

As a music enthusiast and a musician, Dr. Goldsworthy and his team have spent years researching ways to improve the experience of music

for cochlear implant users. Their most recent paper (available here), which was co-authored by graduate student Andres Camarena and medical student Grace Manchala, set out to examine exactly how cochlear implant users perceive harmonies.

They did this by setting up an at-home test via a web app, which played two notes together at a time and asked participants to rate what they heard on a scale of pleasantness. The study not only compared cochlear implant users to normal-hearing listeners, but also captured the participant's musical sophistication—how much they knew about music, how much they'd studied music, their own musicianship.

Previous studies on this topic had concluded that cochlear implant users were largely incapable of distinguishing pleasing or discordant harmonies. This surprised Dr. Goldsworthy, who runs a weekly music appreciation meeting for cochlear implant users (you can read more about the Cochlear Implant Music Hour here), and who had seen first-hand how cochlear implant users were capable of very sophisticated appreciation of melodies and harmonies.

"Science often follows careful observation. Knowing many cochlear implant users who are lifelong musicians allowed my lab to better understand the importance of experience for relearning how to hear subtle differences in harmony," Dr. Goldsworthy said. "The Cochlear Implant Music Hour showed us that many cochlear implant users have excellent access to harmony."

The findings of the study were astonishing. While average cochlear implant users indeed had a much rougher perception of pitch changes than the average listener's (the former were able to hear pitch changes of about 10%, compared with an average listener's 1%), the highest-performing cochlear implant users were able to distinguish pitch differentiation at about the same rate as average users. More surprising

still, the thing that seemed to differentiate ability to hear differences in pitches most among cochlear implant users, aside from the technological issue of being able to hear small modulations in the stimulation that allows the user to hear, was musicianship and musical sophistication.

"The science did naturally follow the observations drawn from the music hour," Dr. Goldsworthy observed. "We were able to design a listening experiment to carefully characterize harmony perception and to connect that to musicianship."

This result confirmed what Dr. Goldsworthy had long known from personal experience: that cochlear implant technology can be improved both through technological progress and through the brain's astonishing ability to learn new skills. Indeed, in his own journey to music appreciation with a cochlear implant, Dr. Goldsworthy discovered that, as technology behind cochlear implants improved, so did his ability to appreciate music—but that, in tandem, just as important was his own evolving appreciation of music as a listener and musician.

"Music appreciation for cochlear implant users is a beautiful meeting of mind and technology," Dr. Goldsworthy said. "Cochlear implant users can improve their music appreciation by bravely diving into music, but there is also plenty of room to improve how sound is encoded into stimulation to allow recipients to dive even deeper."

The results of the study provide quite a bit of hope for cochlear implant users longing to enjoy a high-level appreciation of music: they show that a similar level of appreciation to normal-hearing listeners is possible with improving technology and learned musical sophistication. Future research in the Bionic Ear Lab will continue to focus on how to move average cochlear implant users' experience of music toward the level that the highest-performing cochlear implant users are currently experiencing—in other words, a similar appreciation of music to that of

normal-hearing listeners.

"Our research aims to carefully characterize music perception for cochlear implant users. The more precisely we characterize music perception, the better we can improve sound processing for further improvements," Dr. Goldsworthy said. "I am excited to work with a vibrant team to broadly improve music appreciation for cochlear implant users."

More information: Andres Camarena et al, Pleasantness Ratings of Musical Dyads in Cochlear Implant Users, *Brain Sciences* (2021). DOI: 10.3390/brainsci12010033

Provided by University of Southern California