Comparing Sound Localization and Voice Discrimination in Noise in Elderly Bimodal and Bilateral Cochlear Implant Users

Jake Wong, Raymond Goldsworthy, Samantha O'Connell, Julianne Papadopoulos

Dept of X, Bridge Institute, University of Southern California, Los Angeles, CA , USA

Bridge **U**nder**G**rad **S**cience **(BUGS)** ***Summer Research Program***

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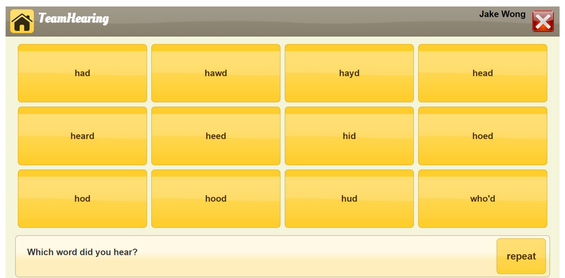
Abstract

As humans age our hearing abilities degrade leading to amplitude reduction, worsened pitch perception, and even deafness. Elderly people specifically struggle not being able to hear, making them much harder to take care of and falling short in various hearing tasks: sound localization and voice discrimination. Luckily, several devices, pioneered using modern technology, have been invented including hearing aids (HA) and cochlear implants (CI). While both these devices are incredible and have enormously contributed to the deaf and hard of hearing, It is unclear which choice is best suited for an individual, specifically between bimodal (CI + HA) and bilateral (CI + CI) fitting. This challenges implant users with bimodal fitting who are interested in making a switch to bilateral fitting need to know if it is worth their while (A surgery to implant an additional cochlear implant may cost anywhere from $50,000 to $100,000). The goal of this study is to compare sound localization and voice discrimination in elderly bilateral and bimodal cochlear implant users to determine. I hypothesize that elderly bilateral fitted implant users will show better results in both the sound localization and voice discrimination tests than the elderly bimodal fitting implant users.

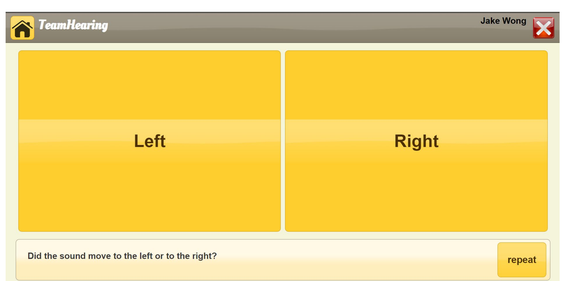
Materials and Methods

Twelve elderly bilateral CI users and twelve elderly bilateral bimodal CI users aged sixty-five and above who were postlingually deaf, and had at least twelve months of experience using a cochlear implant completed a set of online perceptual sound recognition tasks (www.teamhearing.org). These tasks included recognition of vowels and consonants in varying noise levels, sentence completion in noise, ILD discrimination, ITD discrimination, sound movement, and binaural benefit.

1) Online TeamHearing test for vowels in sound:



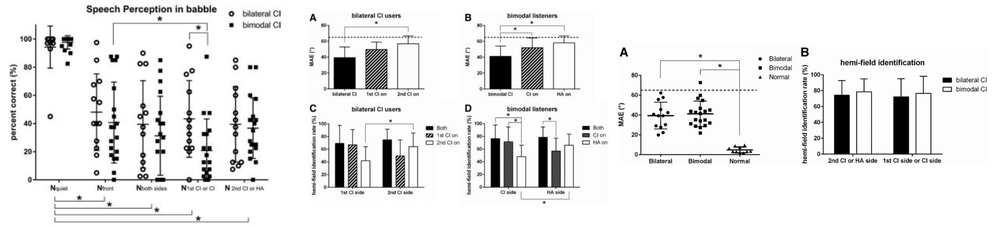
1) Online TeamHearing test for ILD discrimination, ITD discrimination, and sound movement:



Not all tests included in the photos above

Related Study

A related study titled, Sound Localization and Speech Perception in Noise of Pediatric Cochlear Implant Recipients: Bimodal Fitting Versus Bilateral Cochlear Implants, presents a similar research question to mine. The article compares sound localization and speech perception in babble in pediatric bimodal and bilateral cochlear implant users similar to my study which compares these conditions in elderly CI users. The results of this study determined that there were no significant differences in sound localization and speech perception in babble, however there was better head-shadow effect for the bilateral implanted participants and performance from the first implanted ear was better than that of the second implanted ear. The conclusion drawn was that if a bimodal performance is significantly lower on speech perception in babble, the child is highly recommended to get bilaterally fitted.



These graphs show the speech perception in babble, localization accuracy results between subgroups on three conditions, and localization accuracy between bimodal and bilateral participants. All results have no significant differences.

Sound Signal Processing Information Loss

The cause of various differences between NH (normal hearing) and CI (cochlear implant) performance can partly be attributed to the loss of information and programming of sound signal processing in CIs. When a sound signal is processed by a CI, it gets encoded by sound processors into sets of electrical signals. These coding programs filter out frequencies above 1500 Hz and frequently mismatch cues. In figure 1, the graph to the left represents a model of signal processing in a normal hearing ear while the graph on the left shows the electric signals produced by a CI; the graph of signals produced from the implant showed less information per millisecond than the graph of the signals from the normal hearing ear. As a result of the lost information, implant users have decreased performances in sound movement, interaural level difference, interaural timing difference, binaural benefit, and even in pure tone detection thresholds (Fig 2, 3, 4, 5, 6). With the loss of these cues, implant users struggle in tasks that normal hearing people do not. Distinguishing the location of sound in space and receiving speech in spatialized background noise can be especially hard. Decreased performance in the ILD, ITD and sound movement tests are related to decreased performance in sound localization tasks, while decreased performance in binaural benefit in dense noise is linked to decreased performance in speech reception in spatialized background noise.

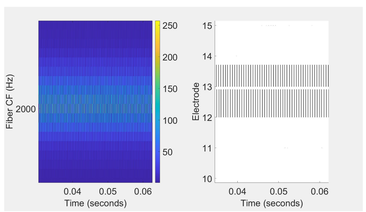


Fig 1.

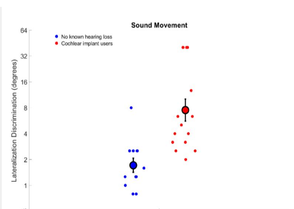


Fig 2.

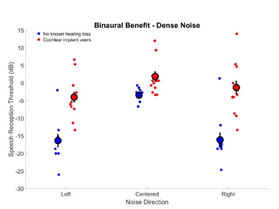


Fig 3.

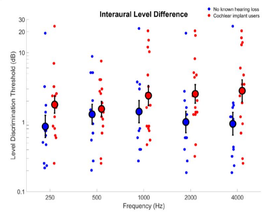


Fig 4.

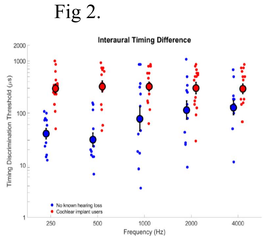


Fig 5.

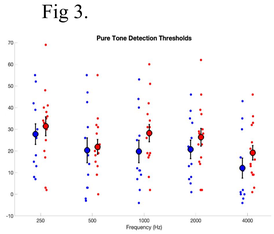
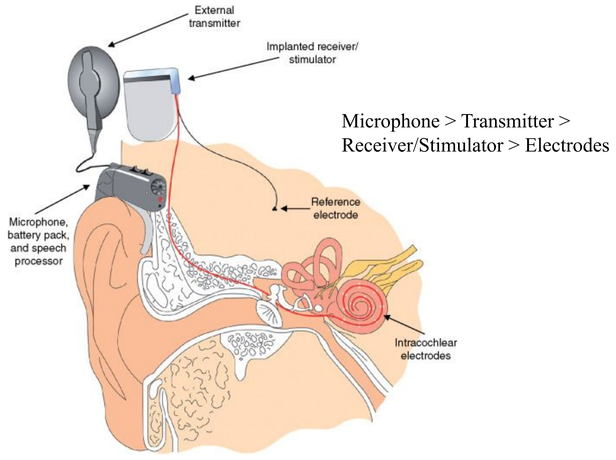


Fig 6.

Figure 1 shows the difference in sound signal processing between a normal hearing ear and a cochlear implant. The cochlear implanted side shows significantly less signals compared to the normal hearing ear. Figures 2, 3, 4, 5, and 6 show performance differences in several tasks related to sound localization and speech reception in spatialized background noise.

Cochlear Implant



A Cochlear Implant (CI) is an electronic device that restores sensorineural hearing loss (inner ear damage) in deaf patients. It works by receiving noise through a microphone, processing and transmitting sound signals, and directly stimulating sensors in the cochlea of the ear.

Summary

- Elderly people with cochlear implants struggle to distinguish the locations of sounds and to discriminate voices in a background noise, hindering aspects of daily life and making it harder to tend to their needs.
- Will elderly bilateral CI users show better results in sound localization and voice discrimination in noise than elderly bimodal CI users or vice versa?
- Methods will include an online survey participants can complete at home.
- A study investigating a similar question was conducted using pediatric participants and showed no major differences between the bimodal and bilateral groups.
- It concluded that if a bimodal performance is significantly lower on speech perception in babble, the child is highly recommended to get bilaterally fitted.
- A leading cause of decreased hearing performance for CI users is the loss of information after a sound is processed.
- The loss of information and certain cues makes it harder for CI users to complete tasks a NH hearer can complete. For example distinguishing the location of sound in space and receiving speech in spatialized backgrounds.
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Resources

Loeb, G.E., and B.S. Wilson. "Cochlear Implant." *Cochlear Implant - an Overview | ScienceDirect Topics*, 2009, www.sciencedirect.com/topics/psychology/cochlear-implant.

Choi JE, Moon IJ, Kim EY, et al. Sound Localization and Speech Perception in Noise of Pediatric Cochlear Implant Recipients: Bimodal Fitting Versus Bilateral Cochlear Implants. Ear and hearing. 2017;38(4):426-440. doi:10.1097/AUD.0000000000000401

Gan, Helena, et al. *Exploring the Binaural Abilities of Cochlear Implant Recipients and Listeners with No Known Hearing Loss Using an Auditory Assessment and Rehabilitation Website*, 2023.

CONTACT US

bridge.usc.edu/bugs