Cochlear Implant and Hearing Aid Research Lab

OHSU

December 2018 Newsletter

History of the Laboratory

The Cochlear Implant and Hearing Aid Research Laboratory (CIHARL) began in July 2010 in the Department of Otolaryngology at Oregon Health & Science University.

The overall goal of the laboratory is to improve patient outcomes with hearing devices, whether they are cochlear implants (CIs) and/or hearing aids (HAs). Our research focuses on auditory perception in children and adults with hearing loss - how they hear and process sounds differently from those with typical hearing, and how these differences explain difficulties with understanding speech, especially in noisy situations like a crowded room.

Laboratory alumni (and names you may remember) include Rindy Ito, Jennifer Fowler, Gem Stark, Emily Walker, Corey Shayman, Rose Dumont, and Nishad Sathe. More recently, several long-time lab members have moved on - Bess Glickman is now in graduate school, Curtis Hartling is now a clinical faculty member teaching audiology at Portland State and Pacific University, and Yonghee Oh has started his own lab as an assistant professor at the University of Florida. Current personnel include Lina Reiss (principal investigator), Morgan Eddolls (research assistant), and Melissa Lawrence (research assistant). We will be hiring a new audiologist and postdoctoral researcher soon – stay tuned! This is the second newsletter and research update written for patients and other individuals who have participated in research in this laboratory.

Welcome Research Assistants!

Morgan Eddolls and Melissa Lawrence joined our lab in the summer of 2018. Melissa graduated with a B.A. in Biology from Whitman College, with research experience in neuroscience. She will be helping part-time with our pediatric studies. Morgan graduated with a B.S. in Biology from the University of Puget Sound, with research experience in auditory neuroscience. Morgan herself has a CI, and enjoys meeting others with CIs and HAs.

Binaural Spectral Integration – fusion of sounds between ears

Over the past five years, we have been

examining how people with hearing loss combine sounds between the two ears – binaural integration. Many labs have studied binaural integration to understand how people know where sounds are coming from. Having two ears helps us calculate the location of a sound source. The brain processes the differences in time of sound arrival and loudness between the ears.

Our lab is the first to look at binaural integration of spectral information. The spectrum of a sound describes how much energy there is at each frequency. A tone (beep) has a narrow spectrum - includes just one frequency or pitch. A noise like "shhhh" has a broad, flat spectrum - includes many frequencies. Spectral information is the basis for how we discriminate between tones, noise, and other sounds like speech.

We first measured how hearing-impaired listeners with HAs and CIs fuse (or combine) sounds of different pitches in each ear into a single sound, using headphones to play different sounds to the two ears. Normal-hearing listeners only fuse different sounds that are very close in pitch, and easily separate sounds differing by more than a tenth of an octave in pitch between ears. We call this "sharp fusion".

In contrast, many HA and CI users fuse sounds that differ by as much as 3-4 octaves in pitch between ears. They are unable to tell that these sounds differ in pitch when presented simultaneously, even though they can discriminate them easily when presented sequentially. For example, a single tone at 550 Hz played into one ear can be fused with tones ranging from 125 to 2000 Hz played to the other ear (about 1 octave below to 2 octaves above).[1] We call this "broad fusion".

However, not all HA and CI users have broad fusion; preliminary findings suggest that people with early onset and long durations of hearing loss are more likely to have broad fusion than those who lost hearing as older adults.[2]

Further research is underway to understand the factors that influence fusion in children and adults, and develop new strategies to correct abnormally broad fusion. One key aspect of this research is our ongoing longitudinal study in children that follows how their fusion changes during development between the ages of 7-12 years, and how it depends on their device combination – normal-hearing, two HAs, CI and HA, or two CIs.

What is the pitch of the fused sound?

Is the pitch of the fused sound heard as the higher pitch, lower pitch, or somewhere in between? It turns out that the fused pitch is often an average of the pitches evoked by the original sounds heard in each ear. This is similar to the way that we average color between the two eyes (remember those blue and red eyepieces for those old 3D movies?). This may reflect the personal experience of many CI users that voice pitch and musical

[1] Published in *JARO* (Reiss, Ito, Eggleston, and Wozny), *JASA* (Reiss et al., 2014), and *Ear and Hearing* (Reiss, Fowler, Hartling, and Oh, 2017)

[2] Presented at the July 2017 CIAP meeting; manuscript in preparation for *Ear and Hearing* (Hartling et al)

pitch seems to change depending on whether they are wearing the CI alone or the CI together with a HA (or a second CI for bilateral CI users)[3].

If binaural integration of simple sounds like tones is abnormal with broad fusion, what does this mean for binaural integration of speech?

Abnormal fusion can cause binaural interference

Recently, our lab conducted a survey to find out how many adults with a CI on one side continue to use a HA on the other side. Out of 40 participants, 29 had continued using their HA, while 11 had stopped using the HA. There were a variety of reasons that people stopped using the HA, including expense to maintain, or lack of perceived benefit.

We also found that several people, even those who continued to use the HA, experienced interference between the CI and HA, especially in noisy situations such as while using appliances, in traffic or wind, or in very loud places like bars or crowded restaurants.[4]

Follow-up testing with vowels, a type of speech sound, confirmed binaural interference in some people who use both a CI and HA, or use two HAs. Participants were tested on their ability to discriminate vowels such as "AH" as in "hot", or "EE" as in "heed", while using one HA or CI at a time, or while both devices together.

Participants with sharp fusion did not experience interference, and usually performed better with both hearing devices. In contrast, participants with broad fusion could experience binaural interference. For example, someone with a good ear and a bad ear would perform worse with both ears.

This study showed that binaural interference is a real phenomenon, and that we need to develop strategies to reduce such interference, especially in individuals with broad fusion.[5]

Abnormal fusion explains difficulties with speech in noise

In collaboration with the National Center for Rehabilitative Research (NCRAR) at the Portland VA, we conducted speech perception testing in an anechoic chamber.

Those of you who participated in that study will remember the open wire floor, and the array of loudspeakers circling the large, sphere-shaped room. Participants listened to a target talker saying the words "Ready, Charlie go to [color] [number] now" in the presence of other competing talkers. They then had to choose the correct color and number. If they got this correct, the

[3] Published in *JASA* (Oh and Reiss, 2017); manuscript in preparation for *Ear and Hearing* (Oh and Reiss)

[4] Manuscript submitted (Montejano, Shayman, et al.)

[5] Published in JARO (Reiss et al. 2017)

background noise became louder (harder). If they got this wrong, the noise became softer (easier). This was adjusted to find the signal-to-noise ratio (SNR) – how much louder the target had to be over the background – for the participant to get 50% correct.[6]

This speech perception testing showed that participants with broad fusion performed worse on this test than those with sharp fusion. This was consistent with the broad fusion participants reporting that the multiple voices fused and blended together, and they couldn't separate them out. In contrast, the sharp fusion participants were able to separate the voices until the background was so loud that it "drowned out" the target.

We also found some normal-hearing listeners with broad fusion that had similar difficulties as the hearing-impaired listeners in this test. This means that it's not just hearing loss alone that explains the difficulties – there is a central auditory processing component involved in binaural fusion that is important for the ability to separate out voices.

Future Studies

New studies are underway to 1) investigate the causes of broad binaural fusion in children and adults with hearing loss; 2) understand how broad fusion affects speech perception in quiet and in noise; 3) develop new ways to program CIs and HAs, or new brain retraining strategies, to sharpen binaural fusion. This work will be very important in helping those with hearing loss and broad fusion to understand speech better, especially in background noise.

Our lab just received a new grant from the National Institutes of Deafness and Communication Disorders (an institute of the National Institutes of Health) to study these questions over the next five years. We will continue with our studies in both children and adults who wear two HAs, a CI and HA, or two CIs, as well as normal-hearing counterparts.

THANK YOU to all of you who have participated in this research!!! These findings would not have been possible without the generous time and support from our research participants and their families.

Please do not hesitate to contact us if you have any questions about the research or if you would like to request copies of publications.

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Current Research Opportunities:

- *Normal-hearing adults (50 to 75 years old) with no hearing loss*
- *Children and adults (10 to 75 years old) with hearing loss:*
  - *bilateral hearing aids*
  - *cochlear implant and hearing aid*
  - *two cochlear implants*

If interested, please email eddolls@ohsu.edu / reiss@ohsu.edu or call our lab at (503) 494 – 5868!

[6] Manuscript submitted (Oh et al.)