Proposal Narrative 2019 Summer Research Grant

Title: Quantifying sound localization cues for hearing aids in “cocktail party” situations

Binaural hearing, or the use of both ears to locate sound sources, is critical for understanding speech in complex listening situations. For instance, imagine you are trying to converse with a friend in the middle of multiple other simultaneous conversations, noises, and reverberations. This complex listening situation is often referred to as the “cocktail party” problem. The ability to hear your friend, or a “target” talker, in a cocktail party scene is partly resolved by the binaural hearing system. For example, binaural hearing cues are critical for spatially separating the target talker from distractor talkers that overlap in time; these cues assist listeners with speech intelligibility in complex acoustic scenes (Swaminathan et al., 2016). Separating target talkers’ speech from other speech and noise in the background is a current goal of advanced hearing aids. However, little verification and validation of these binaural hearing features has been accomplished outside of the manufacturers who developed the products. Here, I propose to measure binaural acoustic recordings of hearing aids equipped with advanced binaural signal processing using speech-in-noise stimuli presented in anechoic and simulated reverberant rooms.

The auditory system is a beautiful yet incredibly complex sensory system. Different from the visual system, to be able to locate an “auditory object”, such as a friend at cocktail party situation, the auditory system must precisely and quickly code speech sounds and noises across many different pitches simultaneously. The auditory pathway to the brain then performs rapid comparisons from both ears at the level of the brainstem to inform the listener where their friend is located, and groups the different pitches of their voice based on precise timing to allow coding of their speech. This complex task can be performed even in the presence of background noise and reverberation, as each sound carries its own precise timing to form other auditory objects within the room. Mathematical models on the auditory pathway have been developed to quantify the frequency information (or pitch cues) and sound localization cues for each acoustic object in a room. These models are now being implemented in high-end hearing aids to help hard of hearing listeners by forming auditory objects, amplifying those objects of interest (target talkers), and attenuating other distractor objects such as background noises and conversations occurring behind the listener.

While it is wonderful that a small device worn in the ear is able to measure and take advantage of these cues important for hearing in cocktail party situations, very few studies have looked at verifying these advanced hearing aid features, and almost no one outside of the hearing aid companies are performing these measurements. It is deceiving to make statements to consumers and Audiologists regarding advanced hearing aid features when they have not been properly verified and validated in realistic test scenarios, as many existing measurements exist only in simulations as opposed to measurements of the hearing aids themselves.

The work proposed here would focus on quantifying two sound localization cues, interaural time differences (ITD) and interaural level differences (ILD), which are needed to locate auditory objects in the horizontal plane. Several sets of high-end hearing aids will be placed on an acoustic manikin used to represent a human head. The acoustic manikin has silicone ears and ear canals to allow for hearing aid placement and contains microphones to measure binaural recordings in the place where the ear drum would be located. Measurements will take place at the National Center for Rehabilitative Auditory Research (NCRAR) located at the Portland VA Medical Center in Portland, OR. NCRAR is equipped with an Anechoic chamber and a circular array of 24-speakers to allow for simulations of reverberant and noisy rooms, such as would be present in a cocktail party scene. Previous experiments have been conducted at NCRAR to quantify ITD and ILD cues for words presented in quiet in anechoic (without echoes) and simulated reverberant rooms. This proposal would allow for me to travel to Portland to make additional measurements on hearing aids in

cocktail party scenes by using the same methodology as Diedesch (2016) with the presence of background noise.

Measurements will be completed within a 2-week period at NCRAR and the recordings will then be brought back to Western to be processed and analyzed using methodology from Diedesch (2016). Processing the files involves taking the two-channel .wav file recordings and running them through previously written binaural models (Akeroyd, 2001) and comparing across room (anechoic, simulated reverberation), noise (with and without background noise present), and program/device (specific hearing aid settings within each hearing aid brand) for measurable differences in binaural cues (ITD/ILD).

Based off of previously work, binaural cues will likely be reduced (Wiggins and Seeber 2011, Picou et al. 2014) or become erratic (Shinn-Cunningham et al 2005) as recordings move from anechoic to simulated reverberation and from using speech-in-quiet to speech-in-noise hearing aid programs. What is not known is whether the addition of noise may further reduce or cause irregularities to binaural cues or if advanced noise reduction algorithms in high-end hearing aid cause no further change to binaural cues.

This work is instrumental to the field of audiology as digital hearing aid features continue to improve but the equipment Audiologists use to verify and validate hearing aids have yet to be updated. These data will be used to help guide hearing aid verification systems used in audiology clinics that wish to implement best practice protocols. Data collected, processed, and analyzed in Summer 2019 will be presented at two conferences in 2020: the American Auditory Society in Scottsdale, AZ in March 2020 and the International Hearing Aid Conference in Lake Tahoe in August 2020. Additionally, these recordings will be used to obtain behavioral data collected at Western in a pilot study which I will use to write an NIH R15 grant proposal examining how individuals weight the binaural cues measured in cocktail party scenes. That work will focus on individualizing hearing aid fittings in the clinic based on weighting of available ITD and ILD cues.

As a recipient of an NIH Loan Repayment Program, I am required to work 20 hours a week in research. I hope to fulfill those requirements partly by collecting data during the summer of 2019 that can be processed, analyzed, and presented at prestigious auditory research conferences in 2020. Data will also lead to at least two publications that I will work on during the academic school year and will benefit both graduate and undergraduate students who may have the opportunity to work in my lab if I attain an NIH R15 grant.

References:

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