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POSTER ABSTRACTS

Topic areas and poster numbers:

ANATOMY and PHYSIOLOGY

Poster # 1

Mechanism of Noise Induced DNA Damage in the Cochlea
O'neil Guthrie, PhD, Northern Arizona University, Flagstaff, AZ

Objectives: It is known that noise exposure induces the precipitation of various types of DNA damage products within cochlear cells. These DNA damage products inhibit vital cochlear processes such as gene expression and protein production. Few research studies have investigated exactly how noise exposure lead to the precipitation of DNA damage products within the cochlea. One hypothesis is that noise exposure induces biochemical cascades that directly damage cochlear DNA while another hypothesis is that noise exposure limits

the capacity of DNA repair enzymes to protect cochlear DNA. Objective: The objective of this research was to determine whether or not noise exposure limits the capacity of DNA repair enzymes to protect cochlear DNA.

Design: Both control and noise exposed rats were deployed and their cochleae were harvested in order to evaluate the expression of DNA repair enzymes within the cochlea.

Results: The results revealed that noise exposure abrogated the expression of structure-specific endonucleases that are important for DNA repair. Furthermore, this effect was associated with the development of significant pathophysiological cochlear outcomes. Interestingly, experimental restoration of the structure-specific endonucleases reversed the noise induced pathophysiological outcomes.

Conclusions: Given that exposure to sounds is ubiquitous to daily life, the current work suggest that sound exposures might subvert genomic integrity by abrogating the expression of protective DNA repair enzymes.

Poster # 2

Effects of Acute Noise Exposure on DNA Damage Response Genes
Li Yang, MS; O'Neil Guthrie, PhD, Northern Arizona University, Flagstaff, AZ

Objectives: Noise exposure as an environmental stressor, shows a broad negative impact on human health. Besides the auditory system, noise exposure disturbs the normal function of the brain, heart, and liver. Today, noise as a systematic stressor is drawing more attention. However, the underlying mechanism for the systematic effect of noise is still unclear. Understanding this aspect is relevant for improving noise induced clinical conditions (e.g. auditory, vascular, neurologic & hepatic). Previous studies have shown that noise exposure induces DNA damage in various tissues. However, the impact of noise on the expression of DNA damage repair genes has not been investigated. ATM/p53/XPC signaling represents a global genomic defense to genotoxic events, and their activity is correlated with the preservation of tissue functions. The current study investigated the effects of acute noise exposure on ATM/p53/XPC expression levels in mice cochlea, cortex, heart, and liver.

Design: In this study, we employed the 129S6/SvEvTac mouse strain (Toconic Biosciences, Inc.). Nine animals were randomly grouped into three different study groups (N=3 per group). The three groups experienced various noise exposure periods of 0 hours (baseline group), 1 hour and 4 hours. ATM, p53, and XPC expression levels were quantified through end-point polymerize chain reactions (PCR) in the cochlea, cortex, heart, and liver.

Results: The combined data revealed that ATM/p53/XPC failed to respond to acute noise exposure in the four tissues.

Conclusions: This result indicates that acute noise exposure potentially blocks DNA damage repair, which could be a reason for noise-induced DNA damage precipitation. Therefore, biomedical intervention is needed to boost DNA damage repair genes in order to limit noise-induced systematic tissue dysfunction.

Poster # 3

Aortic Stiffening and Central Blood Pressure with Age-Related Hearing Loss
Lynn M. Bielski, PhD; Bradley Fleenor, PhD, Ball State University, Muncie, IN

Objectives: The cochlea is a small organ, supplied with blood by a single artery making it susceptible to damage as the vasculature becomes dysfunctional. Thus, interruption in blood flow to the cochlea and/or changes in vascular stiffness or blood pressure may contribute to hearing loss. Previous research using traditional peripheral (brachial artery; arm) measures of blood pressure have provided conflicting evidence to support the role of the vasculature in hearing loss. Non-invasive measures of central (aortic) arterial stiffness and blood pressure have been shown to provide additional insight into cardiovascular health that have not been examined in older adults with hearing loss. The purpose, therefore, of the present study was to examine arterial (aortic) stiffness and central blood pressure in older adults with and without age-related hearing loss, or presbycusis. We hypothesized that older adults with hearing loss would have greater arterial (aortic) stiffness and central blood pressure compared to those with normal hearing.

Design: Eight participants between the ages of 60 and 70 years completed the study. They were non-smokers, with normal blood pressure, with a generally inactive lifestyle. Those with a history of head injury, diabetes, stroke, heart attack, hearing loss present at birth, hypertension, and/or current hearing aid use were excluded. All participants completed a hearing evaluation and measures of the "gold standard" carotid-femoral pulse wave velocity (cfPWV) to assess aortic stiffness and non-invasive peripheral (brachial) and central (aortic) blood pressure measurements.

Results: Results indicated no differences in resting heart rates, systolic and diastolic brachial and aortic blood pressures, cfPWV, weight, height, and BMI between those with normal hearing and those with hearing loss. Notably, central pulse pressure (systolic minus diastolic blood pressure) was higher in hearing loss compared to normal hearing participants.

Conclusions: Our preliminary findings suggest that central measures of blood pressure may be related to age-related hearing loss. Additional studies are required to support our preliminary findings. Alternative measures of cardiovascular health will be discussed.

Poster # 4

The Electrophysiological Effects of Neurotrophins on the Central Auditory System

Momoko Takahashi, BS; Jason Sanchez, PhD, Department of Communication Sciences and Disorders, Evanston, IL

Objectives: Advancements in molecular techniques have provided powerful tools to address sensory receptor degeneration that contributes to hearing loss. One such tool is nerve growth factor proteins, called neurotrophins, which have recently gained attention as therapeutic targets because of their capacity to reverse neuronal degeneration. However, much is still unclear about neurotrophic effects, and therefore research into neurotrophins is critical and timely. Neurotrophins are ubiquitously found in the nervous systems and play diverse and numerous roles, from establishing and enhancing synaptic transmission to regulating neuronal architecture. Such functions are determined by various parameters, including developmental stage, neuronal location, and activation of specific cellular pathways. Until recently, neurotrophins were thought to be transported from the central to peripheral systems. However, recent research has shown that neurotrophins can be transported from the periphery to central systems. It is therefore plausible that locally applied neurotrophins to the auditory periphery can have unforeseen effects in the central pathway, and such effects would be clinically relevant when using neurotrophins to address hearing-related deficits.We therefore characterized the functional effects of two different classes of neurotrophins found endogenously in the central auditory pathway.

We are specifically targeting BDNF and NT-3, both of which have promise as possible therapeutic targets in the auditory periphery. Based on previous work, we hypothesize that both neurotrophins will have bidirectional effects on neuronal properties in the cochlear nucleus. We predict each neurotrophin will dynamically alter action potential firing properties by regulating different aspects of voltage-dependent potassium channels.

Design: Neuronal electrophysiological properties in the avian cochlear nucleus post-hearing onset were examined using whole-cell patch-clamp electrophysiology after exogenous application of BDNF (n=12) or NT-3 (n=11). Several properties were examined to determine the effects of neurotrophins on potassium channels that control the speed and ease with which action potentials occur, specifically the levels of current passing through the membrane at various voltage levels, and the fall rate (repolarization) of an action potential trace. These properties were then compared to control neurons where no exogenous ligands were applied (n=10).

Results: The application of BDNF and NT-3 each displayed different effects on auditory neurons post-hearing onset. We observed no changes in potassium current at high membrane voltages for BDNF application compared to the control. The rate of action potential repolarization was also unchanged. Interestingly, at lower membrane voltages, BDNF application significantly increased potassium currents. This suggests that BDNF acts specifically on low voltage activated potassium channels and helps control action potential firing probability. On the other hand, NT-3 application significantly increased outward potassium currents at higher membrane voltages, thereby increasing the fall rate and quickening the repolarization phase.

Conclusions: Taken together, BDNF and NT-3 caused significant changes in the action potential properties observed in the central nervous system. The changes were voltage- and potassium channel-type dependent. We conclude that BDNF and NT-3 will affect the central auditory system in different ways. As such, the effects of neurotrophins currently considered as therapeutic targets for the peripheral auditory system must be thoroughly examined to properly deliver treatment without downstream adverse effects.

Poster # 5

Differences in Sylvian Fissure Morphology between Schizophrenic and Normal Brains
Maggie Schefer, BS; Jillian Bushor, BS; Carrie Clancy; Bryan Wong, BS; Frank Musiek, PhD, University of Arizona, Tucson, AZ

Objectives: While less common in the general population, approximately 60-80% of individuals with schizophrenia experience auditory hallucinations. Although it is possible to have hallucinations that affect all of our senses, auditory hallucinations are one of the most common types of hallucinations; they can be described as sensations that occur in the absence of an external stimulus. Auditory hallucinations can vary greatly in terms of complexity, clarity, number of speakers, and other factors. It has been theorized that auditory hallucinations may be related to abnormal anatomy and processing in the central auditory system, specifically the left auditory cortex. Here, we aim to identify typical and atypical morphology of auditory structures that may be responsible for contributing to auditory hallucinations. There are significant anatomical variations seen within the primary auditory cortex structures in both normal and pathologic brains. These anatomical variations depend on the morphology of the peri-Sylvian structures within the superior temporal plane (i.e., Heschl's gyrus, planum temporale, & planum parietale) as well as the length and angle of the Sylvian fissure and posterior ramus. Specifically, the angle of the ramus will affect the size of planum temporale and subsequently planum parietale.

Design: Typically, the Sylvian fissure is described as being relatively straight, sometimes containing a posterior ascending ramus and/or posterior descending ramus. Previous work from our lab has also reported a frequently

occurring false ascending ramus (FAR) and trifurcation branching patterns, with a posterior ascending ramus (PAR) morphology occurring in over 80% of 58 brains observed. For this study, we classified the posterior rami into five categories, posterior ascending (occurring at 45 degrees or greater, vertical to the Sylvian fissure), posterior descending (same as the PAR, but in a downward deflection), straight posterior extension (SPE), and either a bifurcation or trifurcation with more than one branch occurring at the posterior recess of the Sylvian fissure.

Results: For this study, we used BrainVisa Anatomist neuroimaging software to manually identify the angle of the posterior ramus in 37 schizophrenic subjects (74 hemispheres) compared to 33 controls (66 hemispheres) from MRI images. Our preliminary results indicate that there were no significant differences in the length of the Sylvian fissure or in the angle or occurrence of the ascending ramus.

Conclusions: More analyses need to be conducted, including views of multiple angles of the ascending rami across brains and interhemispheric comparisons. By taking and examining these additional measurements on the rami and Sylvian fissure, we will be able to identify the impact on Heschl's gyrus, planum temporale (PT) and planum parietale (PP) morphology in pathologic brains compared to controls. This data, in addition to our completed data, will be reported in April.Being able to correctly identify morphological patterns in the branches of the posterior Sylvian fissure may lead to more accurate classifications of auditory structures in the posterior peri-Sylvian areas. This investigation will shed light on the differences in rami between pathologic and non-pathologic populations.Due to large variation in rami patterns in normal brains, understanding the typical branching patterns within pathologic brains may allow for more accurate identification and interpretation of auditory structures during lesion and imaging studies of schizophrenic populations.

Poster # 6

Cool Otoprotective Ora Lavage (COOL) Therapy for Cisplatin Induced Hearing Loss

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Objectives: Ototoxicity from cisplatin remains a significant concern; it is estimated that 70-100% of patients undergoing cisplatin treatment incur ototoxic adverse events including hearing loss, tinnitus, and dizziness. Currently, a number of investigators are exploring pharmacological otoprotectant strategies for cisplatin induced hearing loss. The overarching concern for pharmacological therapies is potential for decrease in the anti-tumor efficacy of the cisplatin and/or need for invasive methods of administration (trans-tympanic or intracochlear perfusion pump). Previous research has demonstrated that systematic and/or localized hypothermia can protect against noise and iatrogenic damage from cochlear implant surgery. Based on this literature, we hypothesized that localized thermal effects may mediate protection from ototoxic drugs. In a proof of concept study, we demonstrated significant protection from hearing loss using cool water ear canal irrigation, while warm water exacerbated hearing loss. However, the study was limited to a single bolus injection of cisplatin and acute time period. Here we aimed to examine application of localized cooling of the ear canal with repeated doses of cisplatin, over an expanded period of time, and using two methods of cooling.

Design: Twenty-four guinea pigs (12 male and 12 female) underwent auditory physiological testing (auditory brainstem response and distortion product otoacoustic emissions at 8-32 kHz) pre and post administration of

cisplatin. The cisplatin (4 mg/kg ip) was administered in 3 weekly single injections for a total of 12 mg/kg. The left ear of the guinea pigs was exposed to either cool water (20°C; ICS Water Caloric Irrigator) or a cool ear bar (15°C, cooled by a Peltier device; TNMTM, Scion NeuroStim) before, during, and after cisplatin administration (total time 30 minutes) while anesthetized. Control animals received same dosing, but underwent a sham treatment. The animals were tested 3 days post each dosage and 1 month post the final dose. At the end of the experiment animals were euthanized for histological evaluation.

Results: The results demonstrated significant reduction of hearing loss in animals that received the COOL Therapy compared to cisplatin-only control animals. No significant difference was observed between the two methods of cooling. Protection was still observed at 1 month post final dose with no further progression in hearing loss noted.

Conclusions: Localized cooling of the ear during administration of cisplatin reduced observed changes in auditory function and loss of hair cells. These findings suggest a novel and minimally invasive otoprotective strategy. We are currently examining mechanisms mediating protection and exploring translation to human populations.

AUDIOLOGY / OTOLOGY

Poster # 7

Effects of Noise Exposure and Tinnitus on Perceived Hearing Abilities

Sara Fultz, AuD; Aryn Kamerer, PhD; Judy Kopun, MS; Stephen Neely; Daniel Rasetshwane, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: Hearing sensitivity and age are both known to be factors related to perceived hearing ability. Some individuals with normal hearing thresholds experience increased hearing difficulty in adverse listening conditions that is sometimes referred to as 'hidden hearing loss' or 'hidden hearing disorder'. However, performance on challenging speech tasks in the laboratory does not always correlate with perceived difficulty. The objective of this study was to determine whether pathologies related to high noise exposure history or tinnitus are driving the lower scores observed on the Speech, Spatial, and Qualities of Hearing Scale (SSQ), a survey of perceived hearing abilities.

Design: 203 adults participated in this study. 102 had normal hearing (NH; audiometric thresholds ,â§ 15 dB HL from 250 - 8000 Hz) and 101 had mild-moderate sensorineural hearing loss and were not hearing aid users. Participants completed pure-tone audiometry, noise exposure history and tinnitus questionnaires, and the SSQ12 questionnaire. Pure-tone average (PTA) was calculated using thresholds at 0.5, 1, 2, and 4 kHz. 116 participants were classified as having high noise exposure by indicating an instance of exposure to loud impulse noise (i.e., gunfire or explosion) without hearing protection. 81 participants were classified as having tinnitus by reporting that their tinnitus symptoms last longer than 2-3 minutes and have persisted for at least six months. Speech recognition was measured using NU-6 word lists in speech-shaped noise, with time-compression, and with time-compression in reverberation.

Results: Across all participants, SSQ scores were significantly lower in individuals with higher PTA. The same was true also within the NH group. Individuals with a PTA of 0 dB HL reported, on average, >20% higher SSQ score than individuals with a PTA of 15 dB HL. NH individuals with low noise exposure and no tinnitus

scored higher on the SSQ compared to any other group. Across all participants and within the NH group only, SSQ was lower in individuals with high noise exposure. SSQ was also lower in NH individuals with tinnitus. Across all participants, there was no relationship between SSQ and speech recognition in any condition after accounting for PTA.

Conclusions: Noise exposure history and tinnitus may influence hearing difficulty independent of speech recognition performance. Individuals with high noise exposure history and tinnitus have lower SSQ scores, even when thresholds are considered clinically "normal", compared to individuals with low noise exposure or no tinnitus. Hearing loss, however, overshadows the effects of high noise exposure or tinnitus on the SSQ.

Poster # 8

"See It Hear It": A New Audiovisual Clinical Tool

Aaron Whiteley, BS; Eileen Lancaster, MA; Sarah Oakley Holbert, AuD; Jamie Bogle, AuD, PhD; Jan Stepanek, MD; Gaurav Pradhan, PhD; Michael Cevette, PhD, Mayo Clinic, Scottsdale, AZ

Objectives: Speech perception testing is the most commonly-used benchmark to assess an individual's performance pre- and post-cochlear implantation. Among the various speech perception tests, the AzBio test is the most frequently chosen assessment. While the AzBio test can observe a patient's speech perception ability in quiet and noise, it may not completely reflect a patient's real-world speech perception performance, as it does not provide information regarding a patient's ability to utilize visual cues from the speaker. Accessibility of visual cues has well-documented benefits for enhancing speech perception abilities, particularly for people with hearing loss. This study aims to assess how much improvement in speech perception cochlear implant users obtain from being able to see a speaker's face.

Design: We have developed a visual supplement to the AzBio test. Our team recorded videos of people speaking the sentences for fifteen AzBio sentence lists. These videos were muted and synchronized with the calibrated audio files of the AzBio sentences. The finished result is videos of people appearing to speak the AzBio sentences, as the audio plays in conjunction with the video. Our clinical tool is called "See It, Hear It." Patients will then be tested in an auditory-only condition and an audiovisual condition. Results will be compared to determine whether a significant improvement in speech perception performance is obtained with the addition of visual cues. Participants will be unilateral cochlear implant users, tested at their routine follow-up appointments at Mayo Clinic. The "See It, Hear It" will be administered in both quiet and noisy conditions. Objective data will be collected in the form of speech perception scores, and subjective data will be collected in the form of patient self-perceived listening effort (rated on scale of 1-10).

Results: While data has not yet been collected, we anticipate that a significant improvement in speech perception performance will be observed when visual cues are added, particularly in noisy conditions. It is possible that a ceiling effect will be observed in quiet conditions. A subjective reduction in listening effort is also anticipated with the addition of visual cues.

Conclusions: Visual cues improve a person's ability to understand speech, particularly in noisy environments. By developing a clinical tool that incorporates visual cues, clinicians will be able to more accurately assess a patient's speech perception abilities in their real world. A demonstration of the task will be available alongside the poster. Beyond this project's potential as a clinical tool, this new evaluation could be used as a form of auditory training. Patients with cochlear implants or hearing aids would be able to use the videos in order to train themselves to incorporate visual cues while listening to speech. It may be used as a counseling tool for

family members of individuals with hearing loss. If spouses and adult children are able to see how their loved one benefits from visual cues, they are more apt to comply with recommendations to ensure their face is visible when speaking to their family member with hearing loss.

Poster # 9

Noise Exposure, Tinnitus, and Hearing Loss among Servicemembers and Veterans
Susan E Griest; Kelly Reavis, MS; Leslie Grush, AuD; James Henry, PhD, VA RR&D National Center for Rehabilitative Auditory Research (NCRAR), Portland, OR

Objectives: Tinnitus and hearing loss are the two most prevalent service-connected disabilities among Veterans in the United States. Little is known about the etiology of these conditions among Service members and Veterans. There is a need to accurately document the types and amounts of noise and solvent exposures before, during, and after military service as well as other risk factors (such as age, gender, years of service, TBI, blast injuries, and other morbidities) to better understand their individual and combined effects on tinnitus and hearing loss. The present epidemiology study is designed to evaluate and monitor a cohort of Veterans for 20 years or more to determine how hearing loss changes over time and how those changes are related to noise exposure and other ototoxic exposures encountered during military service.

Design: The Noise Outcomes in Service members Epidemiology (NOISE) Study is a longitudinal epidemiologic study designed to examine long-term effects of military and non-military noise exposures on auditory functioning among Service members and Veterans. To date over 900 Service members and Veterans have enrolled in this study. The Lifetime Exposure to Noise and Solvents Questionnaire (LENS-Q) was designed to obtain a comprehensive, lifetime history of exposure to noise and solvents. Exposures before, during, and after military service are obtained, including duration, frequency, and use of hearing protection—all included in an 18-page, scannable questionnaire. The questionnaire is described and results from baseline data collected for 690 participants enrolled in the NOISE Study are presented.

Results: For this relatively young cohort, 16% exhibited hearing loss, defined as average hearing threshold >20 dB HL in the conventional audiometric range. Forty percent exhibited hearing loss in the extended-high-frequency audiometric range using the same criterion (average hearing threshold >20 dB HL). Certain factors were found to be associated with poorer hearing in both conventional and extended-high-frequency ranges, including age, type of military branch, years of military service, number of military deployments, noise exposure, tinnitus, and a positive screen for post-traumatic stress disorder. The current findings showed no statistically significant associations between gender, probable TBI or exposure to a blast wave. A multivariate regression analysis was conducted to evaluate which associated risk factors or combination of risk factors significantly predicted hearing loss.

Conclusions: The information obtained from this longitudinal study could be used in future resource planning with the goal of preventing, as much as possible, the development of hearing loss during military service, and the exacerbation of prevalent hearing loss after military service and over Veterans' lifetimes.

Poster # 10

Titan and HearID WAI Measurements in the Same Human Ears
Auden P. Balouch; Sylvie Rosenstein; Nicholas Horton; Susan Voss, PhD, Smith College, Northampton, MA

Objectives: The goal of this work is to compare WAI measurements made within the same live human ears using two FDA-approved WAI measurement systems (HearID from Mimosa Acoustics and Titan from Interacoustics) in order to quantify systematic differences between the two systems. A second goal is to determine if differences in probe insertion depth and corresponding ear-canal cross-sectional area are responsible for differences between the two systems when measurements are made in-vivo.

Design: WAI measurements were made sequentially using the HearID and Titan systems on left and right ears from 169 subjects, which were selected to include equal numbers of females and males with a uniform distribution of age18 to 80 years. Silicone molds were made of each ear canal in order to measure the ear canal's cross-sectional area at the measurement location. For measurements with HearID, the insertion depth was assumed 12mm medial to the intertragal notch because the HearID foam eartip is 12mm in length. The insertion depth corresponding to the Titan probe was estimated using an acoustic method that compared the ear-canal half-wavelength resonances between impedance measurements made with the two systems and determined the relative probe locations. Areas specific to each ear and each probe location were then used to calculate the power reflectance measured with HearID and Titan; these measurements were compared to the factory calculation that assumes a default ear-canal area of 44 and 50mm2 for HearID and Titan, respectively.

Results: At frequencies below 1000 Hz, the mean power reflectance measured and calculated by HearID was systematically about 0.1 larger than that measured and calculated by Titan. Above 1000 Hz the differences were smaller. The measurement location of the Titan probe was systematically further from the tympanic membrane than the measurement location of the HearID probe (6.7±2.6mm, mean±std). Additionally, the more shallow insertion depth was associated with a larger ear-canal area for most Titan probe locations as compared to HearID probe locations with a Titan area of 91±28mm2 and a HearID area of 62±14mm2 (mean±std). When the actual measured ear-canal area for each individual measurement was used to calculate the power reflectance, differences between the HearID and Titan power reflectance measurements were substantially reduced.

Conclusions: Systematic differences that occur in WAI measurements made on the same ear, in-vivo, with the HearID and Titan systems, appear to result largely from differences in ear-canal areas at their respective measurement locations. Moving forward, the ear-canal area used to calculate power reflectance (or absorbance) should account for variations along the length of the ear canal that relate to insertion depth as well as population variations that might occur across sex and age.

Poster # 11

Titan and HearID WAI Measurements in an Artificial Ear

Sylvie L. Rosenstein; Auden Balouch; Nicholas Horton, PhD; Susan Voss, PhD, Smith College, Northampton, MA

Objectives: The goal of this work is to compare WAI measurements made within the same artificial ear using two FDA-approved WAI measurement systems (HearID from Mimosa Acoustics and Titan from Interacoustics) in order to determine whether or not there are systematic differences between the two systems when all other factors are controlled. A second goal is to determine if differences in probe insertion depth can be determined using acoustical methods of quarter-wavelength resonances, acoustically estimated changes in volumes, or group delay calculations.

Design: WAI measurements were made sequentially using each of the HearID and Titan systems inserted into a Larson Davis artificial ear. Methods were developed to assure that the probes of the systems were at the same measurement location. Measurements were repeated with both systems at ¬±2.2mm increments.

Results: Impedance and reflectance measurements were made at the same locations within the artificial ear with both the HearID and Titan systems. Impedance measurements made at the same location were similar for both systems and changes with location were consistent for both systems; for example, the low-frequency impedance magnitudes and the frequencies of the quarter-wavelength resonances were nearly identical for the HearID and Titan measurements. At the same time, while the power reflectance was similar between the two systems for frequencies below 1500 Hz, the power reflectance measured with the Titan system was systematically 0.05 to 0.1 higher from 1500 to 5500 Hz. Additionally, impedance measurements made at locations that varied across ±2.2mm were used to estimate the relative probe location using quarter-wavelength resonances, equivalent volumes, and group delays; the most accurate acoustical method to estimate differences in probe location was changes in the quarter-wavelength resonance.

Conclusions: Differences in WAI measurements made with the HearID and Titan systems within the artificial ear are far more consistent than measurements made with the two systems in-situ in living human ears. We hypothesize the larger in-situ differences between the two systems result from differences in their probe insertion depths and corresponding variability in ear-canal cross-sectional area. Supported by: R15 DC014129-02 from the NIDCD

Poster # 12

Pure-Tones and Self-Report Alcohol Use in Young Adults

Rebecca Anne Vieira; Shannon O'Donnell, BA; Amanda Duren; Athena Doss; Domok Min, BA; Yuti Chu; Mark Reed, PhD; Peter Torre III, PhD, San Diego State University, La Mesa, CA

Objectives: The effects of alcohol on the auditory system in young adults are not well understood.Alcohol use is likely to occur in a noisy environment and as a result can be a risk factor for hearing. The purpose of this study was to evaluate the association between self-reported alcohol use, personal music system use, and pure tone thresholds in young adults.

Design: Fifty-five undergraduate students, 42 women and 13 men (mean age= 21.7 years: SD= 3.3 years) participated in the study. A survey was administered to obtain basic participant characteristics and self-reported alcohol and personal music (PM) system use. Otoscopy and tympanometry were completed to ensure normal outer and middle ear function. Pure-tone thresholds were obtained in octave band steps from 0.25 through 8 kHz, including interoctave frequencies 3 and 6 kHz. Three pure-tone averages (PTA) were calculated per ear. Low-frequency PTA (LFPTA) consisted of 0.25, 5, 1, 2 kHz thresholds, mid-frequency PTA (MFPTA) consisted of 0.5, 1, 2, 4 kHz thresholds, and high-frequency PTA (HFPTA) consisted of 3, 4, 6, 8 kHz thresholds. Self-reported alcohol use was defined as drinks per month (DPM), categorized as No, Light (≤8.5 drinks), and Heavy (>8.5 drinks). Self-reported PM system use with earphones was defined based on a survey question. Can Hear was comprised of participants who reported they could easily hear people or have a little trouble hearing people when using a PM system with earphones. Cannot Hear included combined responses of: have a lot of trouble hearing people and cannot hear people while using a PM system with earphones.

Results: For all three PTA measures, participants were within normal limits for both ears, although the means for both LFPTA and MFPTA were slightly higher compared to the mean HFPTA. Twenty-five participants

reported No DPM, 15 reported Light DPM and 15 reported Heavy DPM.Forty-three participants reported Can Hear and 12 reported Cannot Hear while using their PM system with earphones. For all analyses, DPM was not significantly associated with any PTA outcome. This association remained not statistically significant after adjusting for self-reported PM system use. However for LFPTA only, women had statistically significant LFPTA compared to men after adjusting for age and self-reported PM system use (estimate = -5.1, 95% confidence interval = -9.7 to -0.4 dB). Women had lower mean MFPTA and HFPTA compared to the means for men, but these differences were not statistically significant.

Conclusions: Over 50% of participants reported Light or Heavy DPM. DPM was not associated with any differences in LFPTA, MFPTA, and HFPTA, even after adjusting for self-reported PM system use. Women had significantly lower LFPTA compared to men. Although DPM was not associated with decreases in PTAs in this sample of young adults, alcohol use likely occurs in a noisy background environment. Therefore, more research is needed to determine how loud those environments are and how much alcohol was OR has been consumed, and how those combined risk factors possibly affect hearing.

Poster # 13

The Burden of Hearing Loss in a Group Care Setting

Sara K. Mamo, AuD, PhD; Kara Wheeler, University of Massachusetts Amherst, Amherst, MA

Objectives: Previous studies have found associations between age-related hearing loss and a variety of negative health outcomes - such as increased social isolation, cognitive decline, and other comorbidities. When thinking about the benefits of hearing loss treatment for older adults, it is important to consider the range of health metrics that could serve as important outcome measures that will impact the overall wellness of the population. The current study investigates the health burdens associated with hearing loss in a group care setting for older adults.

Design: Data were collected across multiple Program for All-Inclusive Care for the Elderly (PACE®) sites to better understand the social and physical health status of PACE participants with hearing loss. PACE participants are 55 years and older, nursing home eligible, and living in the community at time of enrollment in the program. Any participant who attends the Day Health Center at their PACE program was invited to participate. All research participants (n = 99, to date) completed a pure tone audiogram, and most (n = 73, to date) opted to participate in a series of questionnaires (Hearing Handicap Inventory for the Elderly-Screener, MOST Cognitive Screener, UCLA Loneliness Scale, IOM Social Determinants of Health, and Instrumental Activities of Daily Living) as well as longitudinal medical chart review.

Results: Results to date (n = 99) suggest a high prevalence of hearing loss, with 71% of participants demonstrating at least a mild hearing loss (> 25 dB HL, 4-frequency pure tone average in the better ear). Data collection is on-going, and a full descriptive data analysis of baseline questionnaires and medical chart review will be reported.

Conclusions: Implications for targeting broad health outcomes important for older adults with hearing loss in group care settings will be discussed. (Work supported by NIH K23DC016855)

Poster # 14

Hearing, Music Listening, and Communication Skills in Adults with Dementia
Tonya R. Bergeson, PhD; Tara Lineweaver, PhD; Allan Diefendorf, PhD; Tim Brimmer, PhD, Butler University, Indianapolis, IN

Objectives: Music therapy or music listening have been shown to have effects on sundowning symptoms, spoken language production, and cognition in adults with dementia in nursing homes. However, these studies assume that all listeners have typical hearing and can appropriate process the music presented to them. A previous study from our group found that approximately 50% of a subset of nursing home residents with dementia had at least partial cerumen impaction. Previous studies have found positive correlations between earwax occlusion and cognitive function. Thus, the objective of the current study is to determine whether treating cerumen impaction benefits the nursing home residents with dementia by improving their response to individualized music playlists, communication, cognition, and sundowning symptoms.

Design: We have tested 36 nursing home residents, all of whom have mild-to-severe dementia and at least partial cerumen impaction in one or both ear canals. In the pre-intervention phase, we consented participants, collected baseline data, including hearing thresholds and tests of language (Western Aphasia Battery), mood (Profile of Mood States-Brief Version), agitation (Cohen-Mansfield Agitation Inventory), and cognition (Mini Mental State Examination and Saint Louis University Mental Status Examination). During this phase we also created individualized music playlists on iPod Shuffles. In the intervention phase, half of the participants randomly assigned to the treatment group received applications of mineral oil drops over a period of 6-8 weeks. The no treatment group did not receive mineral oil drops. All participants listened to their playlists 2-5 times per week and sundowning symptoms were observed and recorded during the intervention phase. We also elicited language samples prior to and after listening to music playlists. We are currently in the post-intervention phase, in which we are collecting the same assessments completed in the pre-intervention phase. Participants in the no-treatment group will receive the mineral oil drops following the post-intervention phase.

Results: We are still in the process of transcribing, coding, and analyzing the collected data. Responses will be measured through documenting changes in sundowning symptoms and communication abilities from before and after music listening, as well as comparing the pre- and post-intervention assessments. We expect that treating cerumen impaction in nursing home residents with dementia will improve their hearing levels, which will have positive effects on symptoms associated with dementia such as affect, behavior, and cognition in response to music listening. Moreover, nursing home residents who are treated for cerumen impaction will be more responsive to individualized music playlists than those not treated for cerumen impaction.

Conclusions: This study will help us better understand how effective music is as a treatment for behavioral and psychological symptoms of dementia, including communication and language skills.

Poster # 15

Assessing Bimodal Benefit in a Virtual Reality Test Environment
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Objectives: Research shows that adults using a cochlear implant (CI) achieve high levels of speech perception after just a few months of implant use. Speech perception in noise is enhanced when a contralateral hearing aid is used alongside the implant (bimodal benefit). The published reports are comprised, mostly, of studies in which speech and noise were presented by a single speaker directly in front of the listener in a sound proof

room. Other studies have used methods in which speech comes from the front, and noise is presented from all around. The extent to which these data translate to real-world experiences is not completely understood. In this study, we expand on previous work by placing implant listeners in a virtual reality (VR) test environment and measuring speech understanding in noise with roving targets. We hypothesize that bimodal benefit will be observed when compared to the CI only condition. Further, we expect that listening in a VR space is more difficult and will produce speech perception in noise scores lower than previous studies conducted outside a VR test space.

Design: The study group includes ten post-lingually deafened adults with unilateral cochlear implantation and a hearing aid on the contralateral ear (bimodal listeners). These participants were volunteers from our local cochlear implant program. Participants were seated in the middle of an 8-speaker array arranged in a 360o pattern. Restaurant noise was delivered come from all eight speakers. The target stimuli were sentences pulled from the IEEE corpus. During each trial a sentence was played from a random speaker and the participant was asked to repeat as much of the sentence as possible. Participants were tested in the unilateral CI and bimodal conditions.

Results: In this study we show that virtual reality test environments can be used to assess speech perception performance of bimodal listeners. The benefits and challenges of this test arrangement will be presented. Speech perception data collection is ongoing and will be presented. The study expects to find enhanced speech perception in noise performance in the bimodal compared to the unilateral CI condition. The study also expects to find bimodal benefit for speech perception in noise, regardless of the speaker presenting the signal.

Conclusions: Speech perception abilities of cochlear implant listeners are known to improve in the bimodal condition. The extent of the benefit in a real-world listening situation is not entirely understood due to the limitations of previous test environments. In this study, we hope to demonstrate how bimodal benefit improves speech perception in noise in a virtual reality test environment.

Poster # 16

Development of an Educational STEM Game to Promote Hearing Health

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Objectives: There is an emerging field of research dedicated to game-based learning which can facilitate health behavior change. "Song of the Star Bird" is a top-down exploration game (in early stages of development) designed to teach Science, Technology, Engineering and Math (STEM) concepts through problem and puzzle solving in order to address predicated shortages of STEM educated workers in the next decade. The game is inspired by Dangerous Decibels, an inquiry-based hearing health promotion program that improves knowledge, attitudes, beliefs and intended behaviors regarding hazardous sound exposure and use of hearing protective strategies in the K-12 populations. The primary objective of the game is to teach STEM concepts and critical thinking within a fun and enjoyable framework. The secondary objective is to encourage positive knowledge, attitudes and intended behavior change in 5th to 7th grade children with respect to protection from the harmful effects of hazardous noise.

Design: FORMATIVE QUALITATIVE STUDY: 1. To develop and test an engaging video game based on the evidence-based Dangerous Decibels® program. 2. To teach STEM concepts associated with the biology and physiology of the auditory system, the physics of sound and wave propagation, and the mathematical constructs

that allow problem solving with numbers. 3. To convey positive hearing health behaviors by focusing on key educational messages related to the prevention of noise-induced hearing loss (NIHL) and tinnitus.4. Subjects: 5th-7th grade students: n=26; 5th-7th grade teachers: n=6; convenience sample recruited from local elementary school. 5. Experimental Protocol: 20 minute game play followed by 1 on 1 verbal interview.

Results: STEM OUTCOMES: The concept that sound becomes louder when moving closer to the sound source was clearly and correctly understood by all of the students. The concept that hearing damage occurs when getting closer to loud sounds was also well understood. The concept of exposure time, while implicit in the game, was not well captured by the students. HEARING HEALTH OUTCOMES: Overall, students clearly identified loud sounds as a threat to their health and understood that the hair cells in the ear can get damaged when exposed to loud sounds. They also understood that if enough damage occurs, the loss of hair cells could lead to hearing loss and deafness. One missing concept was that related to duration of exposure which was not clearly recognized by the students. QUALITATIVE ANALYSIS: A global analysis of the verbal interview responses and recorded interviews were transcribed and coded into NVivo. The results will be share d in terms of attitudes toward the game, and implicit and explicit learning outcomes.

Conclusions: Serious gaming looks promising as a means of understanding STEM concepts and hearing health concepts. Gaming requires a different approach to education; more implicit and less explicit content. Qualitative research design is useful for capturing the implicit knowledge. Students and teachers respond positively to the use of Song of the Starbird in classrooms. Development of the full game and associated teaching materials is now underway through Phase II SBIR funding from the National Institute of General Medical Sciences.

Poster # 17

Use of Wideband Acoustic Immittance for Evaluating Eustachian Tube Dysfunction

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Objectives: In eustachian tube dysfunction, the functions of the eustachian tube, which equalize pressure and ventilate the middle ear are compromised, resulting in symptoms that may include pressure, pain, muffled hearing, and inability to rapidly self-equalize middle ear pressure following changes in ambient pressure. Eustachian tube dysfunction is commonly seen in ear, noise, and throat clinics, with an estimated prevalence of about 4% among adults in the United States. Based on a review of the Military Health System's electronic medical record, eustachian tube dysfunction affects up to 100,000 military beneficiaries, 40,000 of whom are active duty Service members. Despite its prevalence, diagnostic criteria consensus for eustachian tube dysfunction is still lacking. Given that eustachian tube dysfunction is understood to be a problem with the ventilatory function of the eustachian tube, in clinical practice eustachian tube dysfunction is defined by symptoms and signs of pressure dysregulation in the middle ear. The Eustachian Tube Dysfunction Questionnaire (ETDQ-7) is the only tool that has undergone initial validation studies; it scores symptoms of eustachian tube dysfunction based on patient-reported outcomes. Some objective tests have been devised to assess the ventilator function of the eustachian tube but the accuracy and validity are unclear and testing equipment is not widely available. Wideband acoustic immittance (WAI) has become a popular diagnostic tool to assess middle ear function over a wide range of frequencies, but research is limited concerning its clinical utility as a test of eustachian tube dysfunction. Consequently, there is also limited research using WAI at 0 decapascal and tympanometric peak pressure to evaluate eustachian tube dysfunction. The objective of this study is to evaluate the use of WAI and the ETDQ-7 to evaluate eustachian tube dysfunction in a military population.

Design: A cross-sectional study design will be used to compare WAI measures and ETDQ-7 results in participants with and without eustachian tube dysfunction. WAI measurements will be completed at 0 decapascal and tympanometric peak pressure. Participants between the ages of 18 to 62 years old will be recruited from the Wilford Hall Ambulatory Surgical Center (WHASC) Otolaryngology clinic. Participants will be asked to complete the ETDQ-7 questionnaire and audiologic/immittance testing.

Results: Results will include descriptive statistics, t-tests, x2 tests, and f-tests conducted by the Hearing Center of Excellence bio-statistician.

Conclusions: With limited consensus on diagnostic criteria for eustachian tube dysfunction, findings from this study of Service members can extend to benefit the civilian population.

Poster # 18

Hearing Loss Prevalence and Sequela in US Primary Grade Students

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Objectives: To describe audiometrically determined hearing thresholds in a longitudinal, nationally representative sample of primary grade school children in the United States and to evaluate the relationship with other hearing health measures, such as, medically-diagnosed otitis media history since birth and parental report of children;s hearing trouble (HT), as well as academic progress assessed by standardized testing at each grade in reading, mathematics, and general knowledge or science.

Design: The Early Childhood Longitudinal Study - Kindergarten Class of 2010/2011 (ECLS-K:2011) studied children (n=18,170) drawn from a national sample of public and private schools in 2010/2011. Information on children's health, including medically-diagnosed ear infections (EIs) and HT, was reported by parents; additional information was provided by teachers, schools, and daycare providers. Children's cognitive, socio-emotional, and physical development were directly assessed. Reading, mathematics, and science scale scores based on the full set of assessment items were calculated using item response theory (IRT) procedures. The IRT scale scores represent estimates of the number answered correctly if children had received all questions in each content domain. Pure-tone audiometry was performed on a subsample of over 3,500 in second, third, and fifth grade. Based on pure-tone threshold average (PTA) over frequencies of 2 and 4 kHz, better ear hearing was classified as excellent (<5 dB hearing level [HL]), good (5-14.9 dB HL), mild hearing loss (15-34.9 dB HL), and moderate-or-worse hearing loss (≥35 dB HL). Mixed model analyses were used to estimate PTA differences and associations with other health or academic assessments.

Results: Annual prevalence of medically-diagnosed EIs was 13.1%, 14.9%, and 11.9% for second, third, and fifth grade. Parent reported "any HT" was 3.2%, 3.0%, and 2.4% for second, third, and fifth grade. Prevalence of better ear mild and moderate-or-worse hearing loss were 10.8% and 0.9% for second, 6.9% and 0.8% for

third, and 6.6% and 0.3% for fifth grade. Some discrepancies were found between parent reported HT and measured hearing PTA, e.g., in second grade, among children reported as having excellent hearing, audiometric thresholds indicated 9.5% had mild hearing loss and 0.7% had moderate-or-worse hearing loss. Among children with measured hearing loss (PTA >15 dB HL), parents reported 14.0% had excellent and 58.0% good hearing. Nevertheless, the PTA was significantly increased among children with parent reported HT versus those without HT ($p<0.001$). Among children with EIs, prevalence of measured hearing loss (PTA >15 dB HL) was significantly higher compared to those without EIs. Children with a history of recurrent EIs (3+ EIs during one or more time periods since birth) also had significantly increased PTA compared to children without recurrent EIs. Children with hearing loss, PTA >15 dB HL, had significantly decreased standardized test scores. The percent decrement averaged across all three grades was 15.7% for reading, 20.7% for mathematics and 33.7% for general knowledge or science (each comparison: $p<0.001$).

Conclusions: Improved screening of school children for hearing health risk factors together with audiometrically measured hearing should result in improvements to academic progress in primary school grades in the United States.

Poster # 19

Audiologic Profiles and Comorbid Conditions in Children with ASD

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Objectives: The goal of the current work was to summarize auditory clinical presentation and comorbid conditions in a cohort of school-age children with autism spectrum disorder in Australia.

Design: A retrospective file review was completed on 96 school-age children with autism spectrum disorder who presented to a “listening clinic” at the University of Melbourne due to parent concerns for hearing. Information on hearing status and comorbid conditions was extracted from audiograms, case histories, and provider reports.

Results: Speech-in-noise deficits on the Listening in Spatialized Noise – Sentence (LiSN-S) test were observed in 39% of patients despite normal peripheral hearing in all but one child who presented with unilateral conductive hearing loss. The majority of children presented with one or more comorbid conditions. Among those, diagnoses of attention deficit hyperactivity disorder (25%), anxiety (23%), and language disorders (13%) were among the most prevalent. Over ¾ of the cohort (83%) regularly participated in one or more ongoing therapies.

Conclusions: Although the rate of hearing loss in children with autism spectrum disorder was comparable to published estimates in neurotypical peers, speech-in-noise deficits were much more frequently identified. Many children with autism had at least one additional comorbid condition; these should be considered by audiologists evaluating and managing children with autism spectrum disorder.

Poster # 20

Psychometric Properties of an Audiological Needs Assessment Protocol

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Objectives: Background: Needs assessment is an important part of the audiological evaluation. A protocol was recently developed to guide this clinical activity. In addition, a clinical tool (a questionnaire based on the needs assessment protocol) was created to support its application in the clinic. It is important to assess the psychometric properties of this clinical tool and to explore its usefulness. Objective(s): To evaluate the validity, reliability and clinical usefulness of a tool designed to assess the audiological needs of individuals with hearing loss.

Design: Methods: Eleven audiology graduate students and four recently graduated audiologists participated in this counterbalanced crossover experimental study (N=15). Prior to data collection, participants followed a two-hour training course about the new protocol and clinical tool. Then, they were invited to assess the audiological needs of two simulated patients (SP). Participants were randomly divided into two groups. Participants of the first group conducted an interview with one SP, complying to the protocol, but without the use of the clinical tool. Following their assessment, they wrote a conventional audiological report. Next, all participants performed another evaluation with the other SP. During this second interview, they were asked to use the assessment protocol, but with the support of the clinical tool/questionnaire. Participants assigned to the second group did the same tasks, but in reverse order. All assessments with SPs were filmed and audiological reports and filled clinical tools were collected. These data were rated by two independent experts.

Results: Results: The experiment is now completed, and data are presently being analyzed. Results and interpretation will be presented at the conference.

Conclusions: Conclusions: A research project is currently underway to assess the effectiveness and applicability of the protocol and the clinical tool in clinical primary care settings.

COCHLEAR IMPLANTS

Poster # 21

Cochlear Implantation Effects on Vestibular Evoked Myogenic Potentials and Absorbance

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Objectives: The objective of this study was to determine if absent air-conduction stimuli vestibular evoked myogenic potential (VEMP) responses found in ears after cochlear implantation can be the result of alterations in peripheral auditory mechanics rather than vestibular loss. Peripheral mechanical changes were investigated by comparing the response rates of air- and bone-conduction VEMPs as well as by measuring and evaluating wideband absorbance responses in ears with cochlear implants and normal hearing control ears. The hypothesis was that presence of a cochlear implant can lead to an air-bone gap, causing absent air-conduction stimuli VEMP responses, but present bone-conduction vibration VEMP responses (indicating normal vestibular function), with changes in wideband absorbance as compared to ears with normal hearing. Further hypotheses were that subsets of ears with cochlear implants would (a) have present VEMP responses to both stimuli, indicating normal vestibular function and either normal or near-normal wideband absorbance, or, (b) have absent VEMP responses to both stimuli, regardless of wideband absorbance, due to true vestibular loss.

Design: 27 ears with cochlear implants (age range 7-31) and 10 ears with normal hearing (age range 7-31) were included in the study. All ears completed otoscopy, audiometric testing, 226 Hz tympanometry, wideband absorbance measures, air-conduction stimuli cervical and ocular VEMP testing through insert earphones, and bone-conduction vibration cervical and ocular VEMP testing with a mini-shaker. Comparisons of VEMP responses to air- and bone-conduction stimuli, as well as absorbance responses between ears with normal hearing and ears with cochlear implants, were completed.

Results: All ears with normal hearing demonstrated 100% present VEMP response rates for both stimuli. Ears with cochlear implants had higher response rates to bone-conduction vibration compared to air-conduction stimuli for both cervical and ocular VEMPs; however, this was only significant for ocular VEMPs. Ears with cochlear implants demonstrated reduced low-frequency absorbance (500 - 1200 Hz) as compared to ears with normal hearing. To further analyze absorbance, ears with cochlear implants were placed into subgroups based on their cervical and ocular VEMP response patterns. These groups were 1) present air-conduction stimuli response, present bone-conduction vibration response, 2) absent air-conduction stimuli response, present bone-conduction vibration response, and 3) absent air-conduction stimuli response, absent bone-conduction vibration response. For both cervical and ocular VEMPs, the group with absent air-conduction stimuli responses and present bone-conduction vibration responses demonstrated the largest decrease in low-frequency absorbance as compared to the ears with normal hearing.

Conclusions: Bone-conduction VEMP response rates were increased compared to air-conductive VEMP response rates in ears with cochlear implants. Ears with cochlear implants also demonstrate changes in low-frequency absorbance consistent with a stiffer system. This effect was largest for ears that had absent air-conduction but present bone-conduction VEMPs. These findings suggest that this group in particular has a mechanical change that could lead to an air-bone gap, thus, abolishing the air-conduction VEMP response due to an alteration in mechanics and not a true vestibular loss. Clinical considerations include using bone-conduction vibration VEMPs and wideband absorbance for pre-and post-operative testing in patients undergoing cochlear implantation.

Poster # 22

Acoustic and Electrical Hearing Changes Over Time after Cochlear Implantation

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Objectives: Combined acoustic and electrical hearing in an ear with a cochlear implant can result in better speech recognition compared to electrical hearing alone. Preservation of acoustic hearing during cochlear implantation in humans is possible in many cases, but often the acoustic hearing is lost several months after the surgery and the underlying causes are poorly understood. We see a similar pattern of acoustic hearing preservation followed by loss in guinea pigs that are implanted in a hearing ear. The objective of the current study was to better understand the mechanisms underlying hearing loss in implanted ears by following several functional measures over time after implantation and by assessing the histological status of the cochlea after long term functional testing.

Design: Subjects were 15 adult male pigmented guinea pigs implanted in an ear with residual hearing. Psychophysical detection thresholds for pure tones (50 Hz to 24 kHz in octave steps) as well as a number of psychophysical and electrophysiological responses to electrical stimulation were followed over time for 7 months or more (up to 2 years) after implantation. Other functional responses included acoustically-evoked auditory brainstem responses (ABRs), electrically-evoked compound action potential amplitude growth functions (ECAP AGFs), psychophysical detection thresholds for electrical pulse trains and sinusoids, ensemble spontaneous activity (ESA) recorded from a cochlear-implant electrode, and electrical impedance. After functional data collection, animals were euthanized and prepared for histological examination to assess conditions that might be associated with hearing loss. Histological evaluations included condition of inner and outer hair cells, spiral ganglion neurons, stria vascularis, and fibrosis and new bone in the scala tympani.

Results: All animals had some degree of preserved acoustic hearing after implantation, but hearing loss relative to pre-implant baseline ranged widely across animals. Averaged across all tested frequencies, losses during the first 5 months post implantation ranged from 3 dB to 60 dB. ECAP AGF slopes and psychophysical detection thresholds for electrical stimulation during the first months after implantation showed reduced electrical hearing soon after surgery followed by recovery and then relative stability. During the period when functional responses to electrical stimulation were stable, acoustic thresholds either remained stable at the elevated levels or in many cases showed further steady increases, eventually becoming unmeasurable in some cases. Within subjects, acoustic threshold changes over time were usually similar at all frequencies. Histological status at the end of functional testing varied widely across animals, but importantly, some animals with a significant amount of hearing loss had little or no hair cell loss and good ESA levels suggesting that disruption of cochlear mechanics was responsible for the hearing loss.

Conclusions: Acoustic hearing loss shortly after implant insertion could be attributed in part to temporary impairment of auditory nerve function, but long term progressive loss was likely due to more peripheral mechanisms. Acoustic hearing loss can occur in cases with morphologically intact and functioning hair cells suggesting that the acoustic loss is due to disruption of cochlear mechanics, perhaps as a result of fibrosis or middle ear pathology.

Poster # 23

Providing Anchors for Measuring Binaural Fusion with Cochlear Implant Users

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Objectives: Accurately measuring binaural fusion can be challenging, especially with individuals with bilateral cochlear implants (CIs), who do not have an accurate reference point. The goal of this study was to validate a measure that uses unilateral stimulation to create a reference point, facilitating accurate measurement of fusion for bilateral stimulation for CI users.

Design: Four bilateral CI users participated in this study. There were eight stimuli, each consisting of a one second vocalizations of /a/, with each stimulus produced by a different individual. Stimuli were randomly presented to either the right, left, or both ears via direct connect. For each stimulus, participants used a dial to change the location of the stimulus and to indicate the size of the image in their head resulting from the stimuli, including whether it consisted of one or two images. The participants were not told that the stimuli would sometimes be delivered to only one ear. There was a total of 72 stimuli, with an equal likelihood of the stimuli being delivered to the right ear, left ear, or both ears.

Results: All four of the participants had correctly lateralized and largely punctate percepts when the stimuli were presented to only one ear, indicating that the unilateral stimuli presented an anchor that consisted of a punctate, unitary sound. In contrast, the image was centered but more diffuse when the stimuli were presented to both ears simultaneously. In half of the participants, these diotic stimuli were perceived as two distinct images, one at each ear.

Conclusions: The results suggest that a unilateral stimulus can be used to provide an anchor for measuring binaural fusion.

Poster # 24

CT-Based Frequency Allocations Improve CI Users' Speech and Pitch Perception

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Objectives: Music perception remains the most difficult listening endeavor for many cochlear implant (CI) recipients, due in part to the frequency mismatch that occurs between the cochlear neural interface and the frequencies allocated by the programming. Due to individual differences in CI users' ear anatomy, electrode array length, and surgical insertion, great variability exists in CI users' implants, but these differences are not typically accounted for by current CI programming techniques. We hypothesized that the use of flat panel computed tomography (FPCT) technology to identify the location of the electrodes within the cochlea and to create custom frequency allocations would improve speech and pitch perception.

Design: In order to assess the impact of FPCT-based CI fittings using custom frequency allocations, we scanned and administered a chronic use study on 12 adult, postlingually-deafened, experienced CI recipients (enrollment is ongoing). Subjects used 3 different FPCT-based programs for 2+ weeks each, and a test battery was administered at the beginning and end of each chronic trial. Speech metrics included words (CNC), vowels (hVd), and consonants (aCa); music assessments, developed by our lab, examined instrument timbre discrimination and puretone pitch scaling. Our fitting methodology involved assigning the center frequency of channels to that of the characteristic frequency (CF) of the corresponding electrodes. During this iteration of the multiphase study, we chose to deactivate electrodes located at CFs >16 kHz, and evenly distribute (logarithmically) the channels for electrodes with CFs from 2 to 16 kHz. Additional FPCT-based maps investigated separately the effects of using a fixed 70 Hz lower bandwidth boundary and the effects of logarithmic vs CF-based distributions.

Results: A small but significant improvement in CNC word scores and puretone pitch ranking was observed using programs with FPCT-based frequency allocations as compared to subjects' clinical programs.

Conclusions: Image-guided fitting is a promising tool, although additional research is necessary to identify optimum use of its findings. While the current sample size is small, this study may have significant implications for all CI recipients, and be especially relevant for very young children and special populations. This project and previous work suggests that an image-based approach to CI mapping may improve pitch perception outcomes by reducing pitch-place mismatch. Future studies in pediatric and newly-implanted CI recipients are needed to assess the full potential of personalized image-guided CI fitting strategies.

Poster # 25

Word Frequency Affects Word Recognition in Cochlear Implant Users

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Objectives: Lexical properties, such as word frequency and lexical neighborhood density, affect word recognition. Word frequency refers to how often a given word occurs in language. Listeners can more accurately identify words that occur more often in language (e.g. "made," "what") than words that occur less often (e.g. "thatch," "laud"). Lexical neighborhood density (LND) refers to the number of words that are phonologically similar to a given sound sequence; i.e., the number of words that differ from that sound sequence by one phoneme. Words with a higher LND (e.g. "bat," "fill") are more difficult for listeners to identify than words with a lower LND (e.g. "choice," "gauge"). These effects are particularly salient in adverse listening conditions, but have not been previously demonstrated in listeners with cochlear implants. The objectives of this work were to evaluate the extent to which sensitivity to lexical properties varies across individuals with cochlear implants, to determine whether this sensitivity is determined by auditory resolution and linguistic experience, and to determine if sensitivity to lexical properties produced meaningful differences in outcomes of clinical word recognition tests.

Design: Seventeen post-lingually deafened adults with cochlear implants were recruited for this study from the Human Subjects Core at Boys Town National Research Hospital. Each participant heard and repeated back five 50-word CNC word lists from the Minimum Speech Test Battery (MSTB). The word frequency and LND of each word were obtained from published corpora. Recognition accuracy was regressed against both properties. Spectral and temporal auditory resolution were assessed using psychophysical measures of spectral ripple and temporal modulation detection. Additionally, a word familiarity rating task was completed to assess linguistic experience.

Results: Logistic regression curves were fit to each participant's correct responses as a function of word frequency and lexical neighborhood density to quantify individual sensitivity to these properties. Results showed a significant effect of word frequency across listeners. An average difference of 18% word recognition probability between the most common and least common words in the MSTB was observed. No consistent effect of LND was found across listeners. Measures of auditory resolution and linguistic experience were unrelated to the effects of lexical properties. Sensitivity to word frequency did not appear to produce meaningful differences in outcomes of clinical word recognition tests.

Conclusions: Word frequency consistently affects word recognition in listeners with cochlear implants, while the effect of neighborhood density is inconsistent across listeners. Sensitivity to these lexical properties varies considerably across individuals. The effect of these lexical properties on word recognition is not related to auditory sensitivity or linguistic experience. Comparisons in performance across individuals depend on the word frequency distributions of the word lists used. This effect is consistent within subjects due to the relatively balanced distributions of word frequency in the MSTB CNC lists, and thus does not substantially alter word recognition outcomes across word lists in the MSTB.

Poster # 26

Cochlear Implant Candidacy: Are Patients Qualifying in +5 dBSNR Benefitting?

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Objectives: This retrospective review examines postoperative speech recognition in patients who qualified for a cochlear implant (CI) in the presence of noise, but not in quiet. We specifically examine noise presented at +10 dB signal-to-noise ratio (SNR) compared to +5 dB SNR, as the latter has become a qualification condition used by many CI centers in recent years. We hypothesize that patients who qualify for a CI only in testing conditions with background noise will receive more limited benefit postoperatively.

Design: A comprehensive electronic medical record review was completed for fifty-eight post-lingually deafened, unilateral CI recipients who were implanted with their first CI between June 2015 and December 2017 (mean age: 72.26 years; range: 20.5-90.6 years). Patients were separated into three groups for statistical analysis: those who met CI candidacy criteria when tested with AzBio sentences in quiet, those who met candidacy criteria when tested with AzBio sentences in noise at +10 dB SNR (not in quiet), and those who meet candidacy criteria when tested with AzBio sentences when tested in noise at +5 dB SNR (not in quiet or at +10 dB SNR). Pre- and one year post-operative speech recognition scores were compared for all individuals.

Results: On average, speech recognition of individuals qualifying for a CI in quiet improved significantly for both AzBio and CNC testing in all SNRs with the CI only and in the best-aided condition (with the exception of testing with the CI only at +5 dB SNR as there was no data available for this condition). On average, speech recognition of individuals qualifying in noise at +10 dB SNR improved significantly for both AzBio and CNC testing in all SNRs with the CI only and in the best-aided condition except for the best-aided AzBio in quiet measures and AzBio at +5 dB SNR with the CI only, which exhibited improvement though this improvement was not found to be significant. On average, speech recognition of individuals qualifying for a CI at +5 dB SNR improved significantly for CNC testing and AzBio testing at +5 dB SNR and +10 dB SNR in the best aided condition. Improvement was observed in the best-aided condition for AzBio testing in all SNRs, though this improvement was not significant. Speech recognition on the AzBio for this group declined when tested with CI only for all SNRs, though this decline was not significant.

Conclusions: This retrospective analysis supports the use of CIs as a valid option for the rehabilitation of patients qualifying at +5 dB SNR. However, given that the amount of improvement in speech recognition was found to be dependent upon pre-operative speech recognition score, clinicians should exercise critical judgment in qualification and patients qualifying for a CI in noise should receive extensive counseling regarding realistic expectations of the amount of improvement in speech recognition that may be expected.

Poster # 27

Cochlear Implant Programming Parameters and Outcomes in Relation to Etiology

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Objectives: This initial analysis of a large dataset of cochlear implant patients aimed to explore the effects of electrode array type, electrode location (apical or basal) and etiology on electrode impedances, programming levels and speech perception scores.

Design: Electronic health records of Advanced Bionics (AB) cochlear implant patients (N = 429) were extracted from the audiology and AB databases at Massachusetts Eye and Ear. Records were collected for patients between May 2003 and July 2018. Records included demographic details, electrode array type, impedances, most comfortable (M) levels and speech perception scores (phoneme and word recognition in quiet). Speech testing was performed using the Consonant-Nucleus-Consonant word test, presented at 65 dB HL in the sound field. Etiologies were obtained from clinical notes. We present a descriptive overview of the data, including its limitations, and preliminary analyses on the effect of electrode location, electrode array type and patient etiology on impedances, programming levels and speech perception scores.

Results: Across etiologies, impedances for electrodes in the base of the cochlea, 9-16 (median = 6.6 kΩ) were higher than those in the apex, 1-8 (4.8 kΩ). Patients with temporal bone abnormalities had the highest impedances (7.7 kΩ for basal electrodes and 5.8 kΩ for apical electrodes). Impedances measured from the CII HiFocus array were highest (6.7 kΩ), while those measured from the HR 90K Advantage / HiFocus ms array were lowest (5.1 kΩ), likely due to differences in electrode contact size. Median M-levels for basal and apical electrodes were similar (136 CL), although there was considerable variance (IQR = 112 – 174 CL). M-levels for patients with otosclerosis (151 CL) were greater than M-levels for patients with Meniere's, meningitis and ototoxicity etiologies (125 CL). M-levels were greatest for patients implanted with CII, 1J and Helix HR90K HiFocus electrode arrays (141 CL). Median phoneme (81%) and word recognition scores (65%) were similar across electrode array types and etiologies, yet the variance was large (IQRs = phoneme = 51% – 90%; word = 27 – 72%).

Conclusions: Impedances varied with electrode location, electrode array type and etiology. M-levels varied with electrode array type and etiology. Speech perception scores were highly variable irrespective of electrode array type and etiology. These preliminary findings suggest that electrode location, electrode array type and etiology can be related to programming levels. More detailed information on the electrode-neuron interface is likely needed to inform individualized programming techniques.

Poster # 28

Recall in Cochlear Implant Recipients: Impact of CVLT-3 Scoring Methods

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Objectives: 1. Determine how various scoring methods on the California Verbal Learning Test, Third Edition (CVLT-3) provide different cognitive profiles in adult cochlear implant (CI) recipients with post-lingual deafness. 2. Assess relationships between the cognitive processes of immediate recall and hearing-in-noise ability. Hypotheses: 1. Varying scoring method will impact the resulting cognitive profile. 2. Immediate recall ability will positively correlate with hearing-in-noise ability in adult CI recipients with post-lingual deafness.

Design: This within-subjects design included 15 experienced CI recipients, recruited from the patient pool at the Center for Hearing and Skull-Based Surgery at The Swedish Neuroscience Institute in Seattle, WA, USA. Various speech perception and cognitive criteria were employed for inclusion. Participants included unilateral

and bilateral CI as well as bimodal recipients. All testing procedures were approved by the Swedish Medical Center Institutional Review Board.Participants were administered the Immediate Free Recall portion of the CVLT-3 which asked them to recall a list of 16 words. CVLT-3 test stimuli are administered using the auditory modality. Two different scoring methods were applied to the data to provide a comprehensive perspective of the cognitive mechanisms underscoring immediate recall. Primacy (first 4 words), pre-recency (middle 8 words) and recency (last 4 words) metrics were calculated in two ways to create serial position curves:1.CVLT-3 Manual Scoring Method: Calculating immediate recall scores for primacy, pre-recency and recency words recalled divided by the total number of words correctly recalled for all regions (i.e., 16 words) 2.Alternative Scoring Method: Calculating immediate recall scores for primacy, pre-recency and recency words divided by the total number of words in a respective region (i.e., 4, 8, and 4 words respectively)AzBio sentences in noise were recorded in the best-aided condition. Relationships between the varied CVLT-3 metrics and AzBio were quantified with correlations and repeated measures analysis of variance (ANOVA).

Results: Significant differences in cognitive profiles depending on the CVLT-3 scoring method used were observed in this sample. Performance comparability for primacy, pre-recency and recency regions to normative data varied for this sample, depending on scoring method used, with variability from trial to trial. While various trial/region-dependent scores revealed significant relationships with hearing-in-noise ability, averaging regional recall scores with the alternative scoring method across 5 trials most strongly related to best-aided hearing in noise ability in CI recipients.

Conclusions: Our work shows that distinct methodologies for the calculation of immediate recall ability yield different results. When employing standard CVLT-3 scoring methods, adult CI recipients demonstrate distinct recall patterns compared to normative data. When employing an alternative scoring method, this population demonstrates similar recall patterns compared to normative data. The relationship observed between immediate recall and hearing-in-noise abilities suggests that immediate recall ability warrants further exploration as a potential predictor for hearing-in-noise outcomes in CI recipients.

Poster # 29

Loudness Growth in Bimodal Cochlear Implant and Hearing Aid Listeners

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Objectives: The aim of this study was to evaluate the growth of loudness in bimodal listeners who use a cochlear implant (CI) and a hearing aid (HA), using categorical loudness scaling (CLS) technique and subsequent derivation of categorical units directly corresponding to Sones (CU-Sone). We hypothesized that the slope of loudness growth would be steeper via the CI than the HA due to the more limited electric dynamic range, and that for most listeners loudness growth would be imbalanced across devices.

Design: We tested 7 bimodal adult CI+HA users with at least 6 months of CI experience and residual hearing in the HA ear (‚â§ 90 dB HL) at 2 or more frequencies between 250 and 1000 Hz. Participants rated loudness of 0.25. 0.5, 0.75, and 1 kHz via headphone on the HA ear, and via direct stimulation of the CI electrodes corresponding to those frequencies. Loudness, converted to CU-Sone units, was fitted with an exponential equation. Additionally, stimulus levels were transformed into "real-world" sound levels to approximate those reaching the CI and HA microphones. The resulting functions were evaluated for slope of loudness growth.

Results: Slope of loudness growth varied across participants. Most participants showed imbalance in loudness growth between electric and acoustic hearing for all electrodes tested. A few participants showed similarity in loudness growth between specific electrode-frequency pairs. As hypothesized, in most cases electric loudness growth was steeper than acoustic. Notwithstanding, bimodal users largely preferred to wear both devices, with 6/7 wearing both between 8-16 hours per day. 5/7 reported that they perceive benefit of bimodal listening, while only 1/7 reported interference.

Conclusions: This preliminary study shows considerable variability in loudness growth in bimodal CI and HA users. It is unclear whether this variability relates to real-world preference and performance, or whether improved balance in loudness would result in subjective or objective improvements. Further research should include other frequencies/electrodes, complex stimuli (e.g., speech), measures of performance and real-world satisfaction/benefit, and how they differ when loudness growth is controlled for.

ELECTROPHYSIOLOGICAL RESPONSES

Poster # 30

Lower Limb Vestibular Evoked Myogenic Potentials Using Auditory Stimuli
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Objectives: This is a replication study. The present investigation was conducted in an effort to determine whether a vestibular evoked myogenic potential (VEMP) can be recorded from lower limb anti-gravity muscles in healthy, neurologically normal adults. These muscles are innervated by nerves emanating from the vestibulospinal pathways. This evoked response, as reported in the literature, can be recorded from several lower limb muscles, including the quadriceps muscle and the gastrocnemius muscle. We refer to this response as the spinal VEMP or sVEMP. If the response can be reliably recorded, clinicians might have a simple, non-invasive tool to measure the neurological health of the vestibulospinal pathways to assist with diagnoses related to postural instability.

Design: Design: This is a replication study. Silver/Silver Chloride disposable electrodes were placed on the belly of the lower limb muscle of interest (active), medial malleolus (reference) and left bony tibia (ground). Attempts were made to record the sVEMP using 500 Hz tone bursts that were presented monaurally through insert earphones at an intensity of 95 dB and at a stimulus rate of 4.3/sec. The bioelectrical activity was amplified x 3000 and artifact rejection was disabled. The electrical activity was filtered between 10 - 1500 Hz and signal-averaged (a minimum of 150 samples were collected for each tracing). During data collection, participants were instructed to stand up on their toes. This maneuver activated the lower limb muscles.Participants: 10-20 young adults, neurologically healthy, with normal hearing or sensorineural hearing loss (conductive hearing loss is known to obliterate these responses). Participants were required to have healthy middle ear status (measured via tympanometry) and present cervical VEMPs, bilaterally (measured at visit). Recruitment was completed via email to students, faculty, and staff at Vanderbilt University.

Results: The present study is ongoing. Preliminary findings suggest that the sVEMP is rarely present and repeatable using the methods outlined in the literature.

Conclusions: Preliminary findings suggest that the sVEMP as outlined in the current literature is unlikely promising as a neurodiagnostic assessment of postural instability.

Poster # 31

Vestibular Evoked Potentials and Auditory Brainstem Responses in ATG16L1dWD Mice

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Objectives: Mice lacking the WD domain (dWD) of autophagy protein ATG16L1 are defective in non-canonical autophagy pathways involved in endomembrane repair and removal (Rai et al. 2019, De Faveri et al 2019). One author (TW) noticed that several dWD mice developed head tilt, suggesting that defects in endomembrane repair may compromise the function of the inner ear. dWD mice and littermate controls were sent to the University of Lincoln-Nebraska for auditory/vestibular assessment.

Design: Seven dWD and four control mice were assessed with vestibular evoked potentials (VsEPs) and auditory brainstem responses (ABRs). Mice were anesthetized with ketamine/xylazine and normothermia was maintained. VsEPs were obtained to linear jerks in 3 dB steps from +6 dB (re: 1 g/ms) to -18 dB. ABR level was varied in 5 dB steps until a response was no longer observed at 8, 16 and 32 kHz. ABR and VsEP thresholds were determined by several experienced investigators. For the VsEP, the latency of the first two positive peaks and the peak-to-following trough amplitude of these first two peaks were determined across levels. To date, in four dWD mice, the inner ear was prepared and observed with electron microscopy.

Results: VsEP thresholds were elevated in the dWD mice relative to the control mice. When compared at a given stimulus level (dB: re 1 g/ms), VsEP peak latencies were significantly prolonged in dWD mice and VsEP peaks were significantly reduced in amplitude. When data were analyzed in terms of dB above VsEP threshold (i.e., dB SL), the dWD and control mice did not differ significantly. ABR thresholds were elevated for the 32 kHz tonebursts (but not 8 or 16 kHz) in the dWD mice compared to controls. Only one of the dWD mice showed a 32 kHz ABR threshold that was in the range observed in the control mice. Electron microscopy in the dWD mice showed absence of otoconia in three of four otolith organs, with the remaining mouse showing a normal complement of otoconia. In the cochlea, abnormal hair cells were observed in various cochlear regions, with these changes (when observed), typically showing modest loss or damage of hair cells and/or stereocilia.

Conclusions: dWD mice show consistent changes in the VsEP which in 3/4 mice studied presented with missing otoconia. Although not always observed, the absence of otoconia explains the elevation of VsEP thresholds in the dWD mice. The results suggest that non-canonical autophagy pathways involved in endomembrane repair and removal are important for maintaining vestibular function where hair cell abnormalities or auditory nerve dysfunction could explain the high frequency hearing loss in the dWD mice, despite only modest (and inconsistent) hair cell changes in the base of the cochlea. One possibility is that these pathways help maintain secretory pathways responsible for trafficking of otoconial proteins to otoconia. Head tilt and loss of otoconia is also seen in mice lacking NOX3 (Paffenholz et al. 2004). This similarity in phenotype would be explained if production of reactive oxygen species by NOX pathways was upstream of non-canonical autophagy pathways involved in endomembrane repair.

Poster # 32

Measures of Cortical Processing in Children with Auditory Neuropathy

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Objectives: Despite earlier age of identification than in past years, predicting the appropriate course of intervention in Auditory Neuropathy Spectrum Disorder (ANSD) can be challenging in infants and young children. The absence of auditory brainstem responses, a wide variability in behavioral presentation, occasional fluctuation in hearing abilities and often a lack of knowledge of the exact underlying etiology contribute to this dilemma. Consequently, the evaluation of possible cochlear implant candidates in this population and the decision making regarding the timing of intervention are not always straightforward. Cortical auditory evoked potentials (CAEPs) provide an objective means of evaluating how the auditory cortex codes cues crucial to speech and language processing with high temporal precision. In many patients with ANSD, CAEPs can be recorded, and their clinical role in assisting with individual management is gaining interest. Here, we review the characteristics of CAEPs recorded in infants and children after their diagnosis of ANSD but prior to treatment. We also examine how the data correlate with spoken language skills at the time of testing and the type of audiologic intervention (hearing aids or cochlear implants) ultimately selected.

Design: A retrospective analysis was conducted on CAEP recordings from 115 ears in 59 pediatric patients (28 females) previously diagnosed with ANSD. CAEPs were recorded following the delivery of the stimulus /da/ between the ages of 1 month and 12 years. The presence and morphology of the responses and waveform latencies are reported along with the medical history, clinical findings, language skills and management strategy.

Results: CAEPs were present in 97 ears out of 115, with an abnormal morphology in 53.1% of the responses. Wave latencies were greater in patients with abnormal CAEP morphology compared to those with normal morphology. In 26 patients with bilateral ANSD and present CAEPs, the P2 and N2 latencies, as well as the interwave P2-N2 latencies, were longer in non-verbal patients compared to those with some degree of spoken language. In 16 patients with unilateral ANSD, abnormal and delayed CAEPs were present in the affected ear, however age appropriate speech and language skills were reported. Of the 20 patients who went on to receive cochlear implants, 8 patients did not have any recordable responses in at least one ear (i.e., 14 ears out of 16). In the other 12 patients who were eventually implanted, abnormal waveform morphology was identified in 71% of ears.

Conclusions: CAEPs are more often than not abnormal in children with ANSD who present with spoken language delays and in those who ultimately benefit from personal hearing devices. As such, the use of data from CAEP testing may be helpful as part of clinical efforts to determine the best course of treatment in infants and young children with ANSD.

Poster # 33

Mapping Cochlear Synaptopathy Using Tone-Evoked Electrocochleography

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Objectives: Permanent threshold elevation after noise exposure or aging is caused by loss of sensory cells; however, animal studies show that hair cell loss is often preceded by degeneration of auditory nerve fibers. The silencing of these neurons degrades auditory processing and may contribute to difficulties understanding speech in noise. We previously showed in normal hearing listeners (Mepani et al., 2019) that thresholds at extended high frequencies (EHFs) were correlated with performance on word-recognition tests, before adjusting for age. This could arise because: 1) neurons in EHF regions normally carry information useful for word recognition, because their low-frequency tails respond in the speech frequency range at moderate SPLs, or 2) EHF threshold shift is correlated with hidden neural damage in standard audiometric range. Here, we use a forward-masking paradigm to probe for differences in cochlear neural function associated with word-recognition performance.

Design: 90 native speakers of English, 18 - 64 yrs old, with normal audiometric thresholds and middle-ear function were enrolled. Hearing sensitivity was measured behaviorally or using DPOAEs at standard or EHFs. Word-recognition performance was assessed using 1) NU-6 word lists of 50 CNC phonemically balanced words at 55 dB HL presented with or without an ipsilateral noise masker at 0 dB SNR or speeded up at 45% or 65% with added reverberation and 2) a modified version of the QuickSIN consisting of sentences in a four-talker babble at decreasing SNRs (from 10 to 0 dB SNR). ABR stimuli were either 2-kHz or 8-kHz tone pips delivered at 85 dB SPL at 11.1 Hz, with or without a 75-msec forward masking noise (octave-wide) centered on the tone frequency. Masking effects were analyzed using hierarchical clustering of the ABR difference waveforms (unmasked minus masked) in response to 8 kHz tone-pips.

Results: Cluster-based analysis of ABR difference waveforms defined 2 groups (30 vs. 54 ears) with significant differences in masker-evoked suppression of AP or N1P1. These groups did not differ in thresholds at standard or EHFs, however, word-recognition performance differed significantly for 2 out of 4 tests: larger masker effects were associated with better performance. In contrast, the same clusters showed no difference in masking effects for 2 kHz-tone pips.

Conclusions: The association between word scores and masking effect is consistent with a difference in cochlear neural function between good and poor performers. The lack of difference in masker effect at 2-kHz is consistent with a prevalence of neuropathy in the basal region of the cochlea in this young population (mean age = 31+-2 yrs).

Poster # 34

Test-Retest Reliability of Cervical and Ocular Vestibular Evoked Myogenic Potentials

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Objectives: To evaluate the test-retest reliability of cervical and ocular vestibular evoked myogenic potentials (cVEMPs and oVEMPs) in healthy individuals. cVEMPs are evoked by high-level acoustic stimuli, recorded from electrodes placed over the tonically contracted sternocleidomastoid muscle (SCM), and reflect saccular and inferior vestibular nerve function. oVEMPs are evoked by vibration or acoustic stimuli, recorded from electrodes placed over the tonically contracted inferior oblique and/or inferior rectus extraocular muscles, and reflect utricular and superior vestibular nerve function. VEMPs can supplement the conventional vestibular test battery by providing differential diagnostic information about the otolith organs (utricle and saccule) and their pathways. VEMPs, relative to conventional vestibular testing, are new assessments and do not have well-defined test-retest reliability. Determining the test-retest reliability of cVEMPs and oVEMPs will provide a better understanding of the stability of the measure over time, help with the development of normative data, and identify the factors indicative of a pathologic VEMP. These are important steps towards the inclusion of VEMPs in the conventional vestibular test battery.

Design: The design was an observational study with two sessions occurring between 3 days and 4 weeks apart. Participants (N = 24, M=26 ¬± 4.84 years) had no history of dizziness, vertigo, imbalance, neurological disease, multiple concussions, middle ear pathology, or limited cervical range of motion. No changes to medical history were reported between sessions. To reduce intrasession variability, all VEMPs were recorded by the same audiologists at the James H. Quillen Veterans Affairs Medical Center and analyzed by a single individual. Two cVEMP conditions were presented (regulated SCM contraction and maximum SCM contraction) and two oVEMP conditions were presented (500-Hz and 250-Hz toneburst stimuli). VEMP outcome measures for all 4 conditions included latencies, amplitudes, thresholds, and asymmetry ratio (interaural amplitude difference). Several test-retest reliability statistics were calculated for each outcome including the mean difference between sessions, mean difference standard deviation, intraclass correlation, method error, standard error of measurement, and minimal detectable difference.

Results: Test-retest reliability statistics for all VEMPs indicated good to excellent reliability depending on the recording methodology and the outcome measure. Latencies exhibited the best stability over time followed by threshold, amplitude, and asymmetry ratio. For cVEMPs, better reliability was identified for the regulated SCM contraction relative to the maximum SCM contraction condition. For oVEMPs, a 500-Hz stimulus yielded better test-retest reliability than a 250-Hz stimulus.

Conclusions: The test-retest reliability of cVEMPs and oVEMPs reported in this study indicated the stability of the measure over time is adequate to complement the conventional vestibular test battery. Methodological considerations including regulating the patient's SCM contraction for cVEMPs and presenting a 500-Hz stimulus for oVEMPs improved reliability. Vestibular pathology may be identified using VEMPs by substantiating normative ranges of VEMP latency, amplitude, threshold, and asymmetry ratio identified in the current study.

Poster # 35

ABR Characteristics to Frequency-Specific iChirps in Monaural and Binaural Paradigms

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Objectives: The aim of the present study was to compare monaurally and binaurally elicited auditory brainstem responses (ABR) to frequency-specific iChirps and tonebursts. Previous research has illustrated that ABRs elicited monaurally using chirp stimuli have greater Wave V amplitudes and lower response thresholds

compared to their click and toneburst counterparts (for 500 and 2000 Hz stimuli). With consideration of cochlear tonotopic organization and the traveling wave delay, chirps are intentionally constructed to elicit temporal synchronicity of auditory nerve firing across a range of frequencies by temporally delaying the high-frequency components in the stimulus design. We explored the differences between frequency-specific iChirp and toneburst stimuli and extend them to binaural paradigms. Moreover, we were interested in the effect that these stimuli might have on the binaural interaction component (BIC), a difference potential derived from the monaural and binaural sums of ABRs to individual auditory stimuli at supra-threshold levels. We hypothesized that within the monaural paradigm Wave V peak-to-peak amplitudes would be larger in responses elicited to the 0.5 and 2 kHz iChirp stimuli compared to their toneburst counterparts, as the available literature has previously illustrated. Moreover, we hypothesized larger binaurally produced Wave V amplitudes for both iChirps and tonebursts across frequency. Lastly, we hypothesized that the derived BIC amplitudes of ABRs elicited to the iChirp stimuli would be larger compared to those elicited by the toneburst stimuli, especially for lower frequencies.

Design: Auditory brainstem responses were measured in 17 normal-hearing listeners. Four iChirp and four toneburst stimuli were constructed with center frequencies of 0.5, 1, 2, and 4 kHz (condensation polarity, presentation rate 27.7/s). Stimuli were presented at 86 dB peak SPL, which was approximately equal to 50 dB nHL. All listeners were presented with stimuli monaurally to the right ear, monaurally to the left ear, and binaurally to both the right and left ears. We recorded ABRs using both ipsilateral and contralateral recording montages (ipsilateral: Cz - Aipsi; contralateral: Cz - Acontra; ground: FPZ, using international 10-20 system references). Test and retest conditions were recorded to 2050 sweeps in each condition for all listeners. Measurements of interest included ABR Wave V absolute latency, Wave V-V' peak-to-peak amplitude, and binaural interaction component amplitude.

Results: In both the monaural and binaural paradigms, we observed larger Wave V amplitudes in ABRs elicited by the 1, 2, and 4 kHz iChirp stimuli compared to their toneburst counterparts. Further, when comparing monaurally to binaurally elicited ABRs, we found that Wave V amplitudes across all binaural conditions were larger for both iChirp and toneburst stimuli across frequency. These findings are consistent with findings from previous studies. Lastly, we observed larger BIC amplitudes for the 0.5, 1, and 2 kHz iChirp stimuli compared to their toneburst counterparts.

Conclusions: The present study extends our understanding of chirp and toneburst stimuli differences applied to binaural paradigms, as well as allowing for consideration for differences between binaural and monaural auditory stimulation. Although differences in amplitude between the high-frequency chirp and toneburst stimuli were observed through both monaural and binaural stimulation, greater differences between monaurally and binaurally elicited ABRs, as illustrated through the BIC, were observed in our low-frequency chirps compared to their toneburst counterparts. As such, our chirp stimuli provided a more sensitive metric for assessing binaural interaction to low-frequency input.

Poster # 36

Subcortical Speech Processing Changes with Age in Preterm Infants

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Objectives: The goal of this study was to investigate changes in subcortical processing of speech in preterm infants at different ages. Previous studies have interpreted speech evoked auditory brainstem responses (cABRs) using a 'source and filter' perspective; where the fundamental frequency aspects represent 'source' or paralinguistic information and the transient, high frequency spectral energy represents 'filter' or linguistic information. Encoding of source and filter content in preterm infants through the brainstem was explored through spectral analysis of cABRs.

Design: The cABRs were recorded at four different ages (33, 35, 50, and 64 weeks gestational age) in premature infants (mean GA at birth= 28.8 weeks) enrolled in the BabyEARS cohort. A total of 36 recordings were obtained from 28 babies, but not always in the same ear, resulting in a total of 30 different ears tested. The speech stimulus (40 ms /da/) was presented at a rate of 11.1/second with alternating polarity. The stimuli were presented through ER-3A insert earphones at a level of either 63 dB nHL (n=32) or 70 dB nHL (n=4). Recordings were obtained through a two-channel vertical montage with electrodes placed on each mastoid (inverting), forehead (non-inverting) and shoulder or low forehead (ground). Responses were filtered using a band-pass filter from 100-3000 Hz and total number of sweeps ranged from 1500-4500. Spectral analysis of each recording was performed using fast Fourier transformations. The spectral magnitude of four frequency regions and their associated noise floors were used for analysis; F0 (103-125 Hz), F1 (160-270 Hz), F2 (401-720 Hz), and HH (721-1120 Hz). Spearman Rho correlations were used to assess the linear relationship between age, transformed to 1/age2, and spectral amplitude of each frequency region.

Results: All cABR recordings were obtained from babies with present waves I, III, and V elicited by a 70 dB nHL click ABR. One recording was obtained from a baby who is suspected of hearing loss and removed from the analysis. Three recordings were not interpretable, leaving a total of 32 interpretable cABR recordings. Grand average spectra from each age group reveal spectral energy above the noise floor. Differences in the magnitude of the spectral response was seen among age groups. Spectral amplitude of F0 and F1 significantly increased with age but no relationship was found between age and F2 or HH.

Conclusions: The significant relationships between F0 and F1 with age indicates that in preterm infants, subcortical processing of paralinguistic information is developing in the first five months of life. Given that no significant relationship between F2 and HH with age was found, development of subcortical processing of linguistic information may not have begun over this age range. Our results are different than those reported in the literature for older infants aged 3-10 months, in which F0 did not change with age but HH increased with age. The opposite was found in these data. It is possible that the development of subcortical speech processing is a continuum in which encoding of source information begins to develop before encoding of filter information. [Funding: NIH-NIDCD R01DC011777].

Poster # 37

Listening Effort Measured Using fNIRS When Target Sound is Moving

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Objectives: We aimed to objectively measure listening effort using functional near-infrared spectroscopy when a target sound is moving. The hypothesis underlying was that the sound with larger angular velocity would

require extra effort to process than the sound with smaller angular velocity and that the processing would require more extra effort when listening them under noise.

Design: 16 healthy participants with normal hearing participated with the formal written consent. Listening

Results: Subjective report using visual analogue scale showed positive correlation with the angular speed of the target sound (r=0.47) and the changes in the concentration difference measured using NIRS (r=0.49). Behavioural accuracy supported the hypothesis showing the faster the target sentence was, the lower the accuracy was. Furthermore, when the target sound is moving faster and under noise, the additional involvement of the temporal and frontal lobes in the right hemisphere was observed.

Conclusions: Our result is in line with the existing literature in that processing fast moving sound, and under noise, would require additional mental effort, evidenced by the decreased accuracy and in the increased concentration difference. Specifically, the recruitment of the additional right hemisphere was suggested to reflect the processing load.

Poster # 38

Temporal Modulation Transfer Functions of Amplitude-Modulated cVEMPs in Young Adults
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Objectives: Cervical vestibular evoked myogenic potentials (cVEMPs) are widely used to evaluate saccular function. cVEMPs can be recorded from the sternocleidomastoid muscle when the muscle is contracted, such as when the head is turned. Typically, transient tonebursts are used to elicit cVEMPs; in this study, we used bone-conducted amplitude-modulated (AM) 500 Hz tones to elicit AMcVEMPs. This novel approach allows the examination of phase-locked vestibular responses across a range of modulation frequencies. Currently, the AMcVEMP temporal modulation transfer function (TMTF) is not well defined. The upper frequency limit has not been established for amplitude or signal-to-noise ratio (SNR). While it has been shown that modulation frequencies close to 37 Hz elicit robust AMcVEMPs, the TMTF has not been examined with a wide range of modulation frequencies. The purposes of the present study were 1) to characterize the AMcVEMP TMTF in young, healthy individuals, and 2) to determine the upper frequency limit of the AMcVEMP TMTF.The hypotheses of the present study were that 1) AMcVEMP amplitude, SNR, phase coherence, and modulation gain will change with modulation frequency, and 2) responses will be present at modulation frequencies greater than 150 Hz.

Design: Young adults (n = 10, ages 22 - 25) with no history of vestibular lesions or middle-ear pathologies participated in this study. Stimuli were amplitude-modulated tones with a carrier frequency of 500 Hz and modulation frequencies ranged from 7 to 403 Hz. Stimuli were presented at 65 dB HL via a B81 bone-oscillator. Subjects maintained EMG activation of 50 µV. AMcVEMPs were analyzed using an FFT-based approach, using amplitude, SNR, phase coherence, and modulation gain analyses.

Results: AMcVEMPs were present for all subjects. Differences in the TMTF shape were noted across different measures. The amplitude TMTF had a sharp peak, while SNR and phase coherence TMTFs had flat shapes across a broad range of modulation frequencies. Amplitude was maximal at a modulation frequency of 29 Hz (mean = 65.97 µV, stdev = 38.30). SNR maintained its peak value at modulation frequencies between 17 Hz and 143 Hz (mean = 14.49 dB, stdev = 2.11), as did phase coherence (mean = 0.89, stdev = 0.14). Modulation

gain also maintained its peak value at modulation frequencies between 17 and 143 Hz (mean = 4.83 dB stdev = 1.99). When examining the upper frequency limit of the AMcVEMP TMTF, present responses were recorded at modulation frequencies as high as 347 Hz.

Conclusions: The AMcVEMP TMTF in young, healthy individuals varies across different measurements. Maximal amplitude was found at a narrow range of modulation frequencies, while maximal SNR, phase coherence, and modulation gain were found to be equivalent over a broad range of modulation frequencies. While previous studies had only tested the AMcVEMP up to 122 Hz, the current study found the upper frequency limit of the AMcVEMP TMTF to be 347 Hz. Defining the AMcVEMP TMTF may lead to a better understanding of typical, as well as pathological findings within the vestibular system.

Poster # 39

CAEP Stimuli and Rate Differences in Normal Hearing Young Adults

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Objectives: Early detection of hearing loss is often accomplished with auditory evoked potential testing. While early auditory evoked potentials can be used for the larger population of patients, current standard practices are insufficient for patients who are at risk for auditory neuropathy spectrum disorder (ANSD). Cortical auditory potentials may be useful for this subset of patients. The goals of this study were to (1) examine the feasibility of recording cortical auditory evoked potentials in a clinical setting and (2) examine the effect of stimulus type and rate on waveform morphology. We hypothesized that it would be feasible to obtain cortical auditory evoked potentials using our typical clinical set-up and that meaningful signals, such as speech, presented at slow rates would be associated with greater precision of measurement of the P1-N1-P2-N2 complex.

Design: This was a prospective study of young adults (18-30 years of age) with normal audiometric thresholds (better than 20dBHL) at 250Hz-8kHz. A 4-electrode montage, Cz-A1, Cz-A2, high-forehead ground was used. Variables included stimulus type (speech "da", 2kHz tone pip, chirp, click) and stimulus rate (0.5/s, 1.1/s). Stimuli were presented at a suprathreshold level (70dB nHL) in one ear. All other recording parameters were held constant. Equipment that is typically used to collect BAER data was used. Subjects were instructed to remain alert and asked to engage in a quiet activity during data collection. For each condition, the P1-N1-P2-N2 waveform complex was marked, if visible, and peak latency and amplitude were recorded. A generalized linear mixed model was used with main effects and interactions of stimulus rate (0.5/s, 1.1/s), waveform landmark (P1, N1, P2, N2) and measure (latency, amplitude). Repeated measures within subject were addressed by a random participant effect, and compound symmetry covariance structure.

Results: A total of 10 participants were enrolled, including 5 females and 5 males. Across subjects, the speech “da” and 2kHz tone pip stimuli elicited the best qualitative waveform morphology compared to the data obtained from the click and chirp stimuli. Lower stimulus rate (0.5/s) was associated with statistically significant mean differences in waveform measures for both 2kHz tone pip ($p < 0.001$) and speech “da” ($p = 0.01$) stimuli. Thus, there is a significant difference between waveforms associated with stimulus rate for both stimuli.

Conclusions: The results of this study demonstrated that cortical auditory evoked potentials can be elicited in a typical clinical set-up. Furthermore, the speech "da" and 2kHz tone pip stimuli, presented at a slow rate elicited more robust responses with the clearest waveform morphology compared to click and chirp stimuli. Statistical

analysis suggest that presentation rate is potentially impactful for cortical auditory evoked responses elicited by both the 2kHz tone pip and speech "da" stimuli. Future studies will examine feasibility of a similar protocol in young children who have normal hearing and hearing loss with the ultimate goal of augmenting our current protocol to better capture information about integrity of the auditory system, particularly from patients who are at risk for auditory neuropathy spectrum disorder.

Poster # 40

External and Middle Ear Influence on Envelope Following Responses

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Objectives: The remarkable phase-locking ability of the auditory system can be non-invasively assayed using envelope following responses (EFRs). However, a recognized challenge across EFR studies is the high between-subject variability in EFR amplitude. Prior studies have indicated that subtle differences in cochlear and neural function may contribute to such variance even among normal hearing adults. Here we argue that differences in external and middle ear filtering also play a significant role in EFR variability, especially at the low <1 kHz) and high >8 kHz) frequencies. The objective of the present study is to delineate the extent to which differences in external and middle ear transfer function influence EFR amplitude. We test the hypothesis that equalizing stimulus levels reaching the cochlea across individuals will lead to reduced between-subject variability.

Design: We test our hypothesis by comparing EFRs elicited by a complex-tone calibrated using the following five techniques: (i) coupler-RMS: the stimulus is calibrated to play at 65 dB SPL in an ear simulator based on its root-mean-square (RMS) level, (ii) ear-RMS: the stimulus is calibrated in-ear to play at 65 dB SPL RMS, (iii) coupler-forward pressure level (FPL): the stimulus is compensated for the ear simulator's transfer function to achieve a flat spectrum and is scaled to 65 dB SPL RMS, (iv) in-ear-FPL: the stimulus is compensated for the test ear's transfer function and is scaled to 65 dB SPL RMS, and (v) 1kHz-FPL coupler: the compensated stimulus in coupler-FPL (iii) is scaled to 65 dB SPL based on the level at 1 kHz. The complex-tone has four bands with 12 equal-amplitude harmonics between 0-1.2 (low), 1.6-3 (mid), 4-5.4 (high), and 8-9.4 (very high) kHz, and corresponding fundamental frequencies of 91, 96, 101, and 106 Hz. This enables simultaneous evaluation of four independent EFRs initiated at different locations on the cochlea. EFRs are recorded differentially between the vertex (non-inverting) and the nape of the neck (inverting) while participants are resting/asleep. Twenty young adults (18-35 years) with normal hearing will be recruited.

Results: Our preliminary data (n=6) indicate that irrespective of the calibration method, EFR amplitudes are the lowest in the very high frequency band. Between-subject variability is the highest for the low frequency band. EFR amplitudes appear to vary as a function of both the frequency band and the calibration technique. Within each frequency band, when EFR amplitudes are compensated using the five methods, the in-ear-FPL produce the highest amplitude EFRs but only at low and very high frequencies. With the next 14 participants, we will compare (i) EFR amplitudes using analysis of variance and (ii) the between-subject variability in EFR amplitudes using the Levene’s test, both as a function of calibration technique and tone complex frequency.

Conclusions: Findings will reveal if advanced calibration techniques such as FPL, that account for individual differences in external and middle ear transfer function, are necessary to reduce between-subject variability in EFR characteristics. Reducing between-subject variability will, in turn, help improve the sensitivity of EFRs in detecting deviant temporal processing.

HEARING LOSS / REHABILITATION

Poster # 41

Measuring the Meaning of Life in Patients with Hearing Loss

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Objectives: As defined by the World Health Organization, quality of life is a broad concept that is largely affected by conditions and disorders. Various quality of life scales have been developed and applied to patients with hearing loss, however, few of these scales include any questions about hearing or communication. Studies indicate existing scales are unlikely to detect a quality of life change due to hearing loss or communication impairment. Therefore, we developed a preliminary questionnaire designed to measure "The Meaning of Life" from a broader perspective that includes items assessing a wide range of life activities including communication.

Design: We recruited 312 adults with tinnitus (n=116) and cochlear implants (n=196) who were research participants at the University of Iowa Hospitals and Clinics for this study. The 23-item Meaning of Life questionnaire was administered using a paper/pencil method, and responses were compared across different groups (i.e., cochlear implants vs. tinnitus, younger vs. older participants, male vs. female) using independent samples t tests. To evaluate validity of the questionnaire, we compared results to similar quality of life scales (e.g., EQ-5D, SF-6D) for 115 tinnitus patients.

Results: Not unexpectedly, the results revealed that hearing is an important aspect of quality of life for cochlear implant users and tinnitus patients. Lower mean ratings were found for cochlear implant and tinnitus groups for the item on hearing, consistent with difficulties that would be experienced by having a hearing disorder. Additionally, lower ratings were reported for items 22 (i.e., I am never depressed, sad, anxious) and 23 (i.e., I never experience pain or discomfort), suggesting that hearing loss can contribute to social isolation, loneliness, frustration and dependence on a caregiver. With regard to tinnitus, tinnitus patients reported significantly more sleep problems than the cochlear implant users. For effects of aging, older participants reported lower ratings for memory and concentration compared to younger participants. Lastly, in terms of gender differences, men and women regard their feelings of satisfaction and happiness differently. Females had significantly higher total ratings and for items assessing friendship, positive outlook, and satisfaction. Compared to similar scales assessing quality of life, the Meaning of Life questionnaire was highly correlated with both the EQ-5D and SF-6D scales, suggesting good construct validity.

Conclusions: Quality of life scales should be sufficiently broad to capture the impact of disability, but sensitive to consequences of a given disorder (e.g., hearing loss). The Meaning of Life questionnaire was found to be sensitive to differences between hearing groups and shows good validity when compared to other quality of life scales. In future studies, we plan to administer this questionnaire to more diverse populations and consider aspects of ethnicity, employment status, among others.

Poster # 42

Personality Characteristics in Deaf or Hard-of-Hearing Children

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Objectives: The purpose of this study is to (1) measure the personality characteristics of grit and mindset in children who are Deaf or hard of hearing and determine if they are correlated, (2) determine whether mindset/ grit scores correlate with academic outcomes, and (3) investigate the relationship between grit/mindset and reported benefits with hearing aids/ cochlear implants. We hypothesize that a growth mindset will be correlated with increased grit and good academic outcomes. Additionally, we hypothesize that mindset and grit will be positively correlated with reported benefits with hearing aids/ cochlear implants.

Design: Participants were Deaf or hard-of-hearing children between the ages of 10 and 18 without a learning disability. Mindset was measured using the Dweck Mindset Instrument and grit was measured using the Grit-S questionnaire. A Qualtrics survey was used to administer the grit and mindset questionnaires and collect detailed demographic information including current school grades, and HA/CI benefits. The online survey was distributed to nationwide agencies involved with Deaf or hard-of-hearing children, non-profit organizations, and school districts across the country. 45 surveys have been collected so far, but the survey will remain open until December 2019.

Results: Results will be shared regarding mindsets and grit scores of children who are Deaf and hard-of-hearing, and their relationship to academic performance and hearing aid/ cochlear implant benefit.

Conclusions: Findings may shed light on the effects of a child's grit and mindset on academic performance and be of benefit to audiologists, speech-language pathologists, teachers, and others who work with children who are Deaf or hard-of-hearing.

Poster # 43

Hearing Loss Affects Emotion Perception of Multisensory Stimuli

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Objectives: Emotions play a key part in determining thoughts and behaviors, and disrupted emotion perception can significantly impact one's everyday life. The purpose of this study was to evaluate the effect of hearing loss on emotional responses to multisensory stimuli. Research has shown that adults with hearing loss demonstrate disrupted emotion perception to auditory stimuli, and those with more hearing loss demonstrate larger disruptions. However, the role of hearing loss configuration has yet to be explored. Given the importance of low frequency audibility to auditory emotion perception, it is possible that flat configurations would be more disruptive than sloping losses. Additionally, previous research has not examined the effects of hearing loss on emotion perception when visual stimuli are added to the auditory stimuli. It was hypothesized that those with bilateral, sloping hearing loss would have a reduced range of emotional responses relative to listeners with normal hearing and relative to listeners with a sloping, high-frequency hearing loss. It was also expected that the addition of visual stimuli would enhance the emotional responses for all types of hearing loss.

Design: Three groups of English speaking adults (50-79 years old) participated. Participants varied in their hearing acuity, but were otherwise matched for age and gender. Participants were categorized as having 1) normal hearing sensitivity bilaterally, 2) normal sloping to severe high frequency sensorineural hearing loss bilaterally, and 3) moderate to severe flat sensorineural hearing loss bilaterally. Participants rated valence in

response to pleasant, neutral, and unpleasant non-speech auditory, visual and auditory-visual stimuli. Thus, all participants made ratings in three conditions: auditory only, visual only, auditory-visual. Ratings of valence were analyzed using linear mixed-effects models. Pairwise comparisons were used to evaluate differences between groups with each stimulus modality within each category.

Results: Analysis revealed those with bilateral hearing loss rated auditory stimuli less pleasant and less unpleasant than the other groups. The addition of visual components did not always enhance the responses in the hearing loss groups to comparable ratings of the normal hearing group. In general, hearing loss did not have a significant effect on emotional responses to neutral stimuli or visual stimuli.

Conclusions: These findings confirm the presence of bilateral hearing loss reduces the range of emotional responses to sounds. The findings extend extant work by demonstrating that hearing loss configuration affects emotional responses; listeners with flatter hearing losses exhibited more disrupted emotion perception than those with normal low frequency hearing. Additionally, the data also suggest the effects of hearing loss might be evident even in the presence of visual cues. Thus, the consequences of hearing loss on emotion perception perseverate despite complementary, multisensory information. This finding has implications for emotion perception in daily life, where patients often encounter multisensory phenomena. Importantly, the data support the importance of audibility for emotion perception and do not support that hearing loss creates systemic chances in emotion processing for non-auditory stimuli. Interventions seeking to aim emotion perception could focus on improving audibility, rather than cognitive or emotional training alone.

Poster # 44

Associations Between Hearing Loss, Loneliness, Social Isolation: A Systematic Review

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Objectives: Hearing loss is highly prevalent among older age cohorts, as is occurrences of loneliness and social isolation. Both loneliness and social isolation are also associated with insidious outcomes such as increased incidences of all-cause mortality and higher prevalence of chronic comorbidities. The purpose of this review is to synthesize published investigations that report on the associations between hearing loss with loneliness and social isolation.

Design: A systematic search through PubMed, Embase, CINAHL Plus, PsycINFO, and the Cochrane Library identified an initial total of 2495 references. Two independent reviewers screened articles for inclusion, with a third reviewer involved for adjudication. Studies published in English of older adults with hearing loss that also assessed loneliness and/or social isolation using a validated measure were included. Investigators used a modified Newcastle-Ottawa Scale (NOS) to appraise study quality.

Results: A final total of 14 articles were included in the review. The majority (12/14) were cross-sectional in design. Assessment methods were varied across hearing status, loneliness, and social isolation. Despite this heterogeneity, most multivariable adjusted investigations revealed that hearing loss was significantly associated

with higher risks for both loneliness and social isolation. Several studies also revealed this association to vary across gender, with women showing a stronger association than men.

Conclusions: Our findings indicate that hearing loss is associated with both loneliness and social isolation, which have important implications for the cognitive and psychosocial health of older adults. Future investigations should further explore possible underlying mechanisms of these relationships, as well as the efficacy of intervention methods through aural rehabilitation programs in addressing loneliness and social isolation.

Poster # 45

Virtual Scenarios for Evaluating Communication, Sensory Aids, and Social Engagement

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Objectives: Hearing-related questionnaires and outcome measures for sensory aid fitting can reveal much about the success of amplification but do not fully reflect the lived experience of many persons with hearing loss. Recently, considerable attention has been focused on social isolation of people with hearing loss and the potential benefit of sensory aids. Though surveys suggest that sensory aids can help reduce isolation, the potential barriers to success are still not well understood. While a link between sensory impairment and social isolation is plausible, this link is unlikely to be direct. Rather, we argue, sensory impairment leads to difficulty in interpersonal interactions which leads, in turn, to reluctance to engage in subsequent interactions. Ultimately, the result may be social isolation. In the intermediate stage, where hearing impairment may manifest as conversational difficulty, we can learn about the functional consequences of the hearing loss and of the sensory aid benefits and limitations. One critical source of interpersonal difficulty may be a lack of shared understanding of the impacts of hearing loss by individuals and their frequent communication partners. In our studies we simulate social scenarios and involve the client and their communication partner in the laboratory. We hypothesize that consideration of the perspectives of both the client and their communication partners may better characterize the challenges of hearing in everyday settings and the benefits of sensory aids for reducing social isolation. To test this, we have developed simulations of multi-conversational scenarios so that clients and their partners can make judgments of sensory aid performance in realistic, but controlled conditions.

Design: Listeners with hearing loss and their partners use a client-oriented scale (adapted from the COSI, Dillon, 1997) and social participation measures (SPARQ, Heffernan et al., 2018) to report challenging listening conditions such as small group conversations in noisy restaurants. Representative scenarios are simulated in the laboratory where clients and partners sit at a 'virtual family table' listening to multiple pre-recorded dialogues. Both make ratings of their perception of the client's ability to understand and effort required in following the dialogues. Following the scenarios, clients and partners re-assess the social participation questionnaire and discuss discrepancies between the client and partner perceptions.

Results: Multiple pairs (clients plus partners) have completed the questionnaires and virtual social scenario testing. In most cases, the partner overestimated the client's perceived understanding of the dialogue content, and underestimated the client's self-reported effort. Client and partner questionnaire results were compared and the match/mismatch between client and partner was quantified. The majority of partners expressed surprise that their understanding of the client's difficulty was limited or inaccurate.

Conclusions: Social engagement can be measured in a semi-controlled laboratory setting in which input from clients and partners can be meaningfully observed. Results are being used to refine methods of directly measuring social engagement to test whether emerging technologies have a beneficial effect on the social isolation caused by hearing loss.

Poster # 46

Impaired Speech in Noise and Depressive Symptoms in Older Adults

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Objectives: The presence of depressive symptoms has been estimated to be between 8-15% in community-dwelling older adults. Additionally, it has been proposed the etiology of late-life depression could be related to behavioral or neural mechanisms- including the possible influence of hearing loss. To date, few studies have investigated the association of depressive symptoms and speech in noise perception ability. Individuals with impaired speech in noise performance and decreased central auditory processing may find it much harder to engage with their surrounding environment and become frustrated with their inability to communicate effectively. To address this research gap, we will quantify how speech in noise perception ability, measured using the QuickSIN assessment, is independently associated with depressive symptoms. We hypothesize poorer speech in noise perception ability is cross-sectionally associated with increased presence of depressive symptoms and change in depressive symptoms, after adjustment for peripheral hearing loss and other clinical and demographic factors.

Design: Cross-sectional analysis from the Atherosclerosis Risk in Communities (ARIC) Study, a longitudinal study of community-dwelling older adults, involving 3,346 older adults from 2016-2017 study visit (visit 6). The association between speech in noise performance ability and depressive symptoms was assessed via the Center for Epidemiologic Studies Depression Scale (CES-D) questionnaire. Speech in noise perception ability was assessed via the QuickSIN assessment, evaluated continuously as number of correct responses as well as via statistical distribution. In a secondary analysis, we investigated change in depressive symptoms from study visit 5 (2011-2013) to visit 6 (2016-2017) by QuickSIN score in 3,206 participants.

Results: Poorer speech in noise perception ability as measured by the QuickSIN is associated with greater depressive symptoms, adjusting for pure tone average, demographics, overall health status and cognition. A five word increase in QuickSIN score is associated with a 17% lower (better) CESD score ($p=0.006$). These results were robust across levels of peripheral hearing. When investigating change in depressive status between visit 5 and visit 6, a 5% ($p<0.01$) decrease in depressive symptoms was noted for every 5 word increase in QuickSIN score among those with low cognitive function, highlighting the potential influence of cognitive status on the association between speech in noise performance and depression.

Conclusions: Results suggest impaired speech in noise perception ability is associated with the presence of clinically meaningful depressive symptoms in older adults, although effect size is small. Poorer speech in noise perception is additionally associated with an increase in depressive symptoms over time, particularly among older adults with poorer cognitive function. These findings support intervention for impaired speech in noise performance through behavioral or communication management strategies or technology as a prevention option for depression in older adults. Further study on the association between speech in noise performance and

depressive symptoms over longer follow-up as well as how change in speech in noise performance affects depressive symptoms is warranted.

HEARING SCIENCE / PSYCHOACOUSTICS

Poster # 47

Contribution of Temporal Processing Measures to Self-Perceived Listening Difficulty
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Objectives: The audiogram, a measure that mainly reflects outer hair cell function, is used to diagnose hearing loss. Some patients, however, report greater degrees of difficulty in challenging listening situations than would be expected based on their audiogram. It has been suggested that some of these individuals may have auditory nerve damage that could cause suprathreshold auditory deficits, including deficits in the coding of the temporal aspects of complex stimuli. The purpose of this study was to determine whether a combination of behavioral and physiological measures that included measures of temporal processing could predict self-perceived listening difficulty, as measured by the Speech, Spatial, and Qualities of Hearing Scale (SSQ12) in a group of participants with normal hearing and mild-moderate hearing loss.

Design: One hundred sixteen adults with normal hearing (mean=35.4 years) and one hundred two adults with sensorineural hearing loss (mean=53.7 years) participated in this study. Participants were included in the normal hearing group if thresholds were ≤ 15 dB HL for all frequencies from 250-8000 Hz. The hearing loss group included participants with pure-tone thresholds between 20 dB HL and 65 dB HL for at least one frequency from 250-8000 Hz. Participants with a range of noise exposure histories, as measured using a questionnaire, were included. Eight predictor variables were combined in a multiple regression model that included age, pure-tone average (0.5-4 kHz), extended high frequency threshold at 11.2 kHz, measures of temporal processing (frequency modulation detection threshold [FMDT], time-compressed speech recognition, time-compressed speech recognition in reverberation, frequency following response), and speech-in-noise recognition to predict the variance in the SSQ12. Relative importance analysis was used to parse the variance explained by the predictor variables.

Results: When the entire cohort of subjects was included in the analysis the predictor variables accounted for 23% of the variance in the SSQ12. Pure-tone average accounted for the largest portion of the variance (8%), followed by FMDT (7%), age (4%) and threshold at 11.2 kHz (3%). Time-compressed speech in reverberation, speech in noise, and frequency following response each contributed ≤ 1% of the variance. Interestingly, these relationships were maintained when the normal hearing subjects were modelled separately, although the total variance explained by the model (19%) was slightly lower than for the combined group. In both models, FMDT, a measure of temporal processing, explained a greater proportion of the variance than speech-in-noise recognition.

Conclusions: While pure-tone average was the largest contributor to self-perceived listening difficulty for both individuals with normal hearing and hearing loss, our results support the notion that temporal processing ability also contributes to self-perceived listening difficulties for both groups. By contrast, speech in noise recognition did not contribute to self-perceived listening difficulty. These factors should be taken into consideration when developing a clinical test battery to address concerns of individuals with listening difficulties.

Poster # 48

"Hidden" Impacts of Subclinical Cochlear Damage and Cognition on Complex Speech Perception

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Objectives: Complaints of hearing difficulty in the context of a normal audiogram are surprisingly common, particularly among noise exposed populations such as military Veterans. Recent studies of "hidden hearing loss" have focused on the impact of noise-induced synaptic loss on complex speech perception in individuals with normal audiograms. Wave I amplitude of the auditory brainstem response (ABR) has been used as an indirect measure of synaptic loss; however, a clear relationship between ABR wave I amplitude and complex speech perception has not been demonstrated. Subclinical outer hair cell (OHC) damage may also negatively impact speech perception. In addition to damage to the auditory system, deficits in aspects of cognition such as working memory and attention are also associated with poorer speech in noise ability. Stressor-Related Disorders common in the Veteran population, such as post-traumatic stress disorder (PTSD), that reduce overall working memory and attention capacity may also impact speech in noise ability. This study investigated indicators of OHC function, synaptic/neural function, and cognitive function on complex speech perception in two samples of young adult Veterans and non-Veterans with normal auditory thresholds. We hypothesized that there would be an interaction effect between OHC function and synaptic/neuronal function on speech perception, with a bigger negative impact of synaptic loss on speech perception when OHCs were also damaged. We also predicted an additive effect of cognition where variation in cognitive ability uniformly improves or degrades speech perception.

Design: Military Veterans and non-Veterans aged 19-40 years with normal audiograms and no history of traumatic brain injury were recruited for two studies aimed at measuring the impact of OHC function (measured with DPOAEs), synaptic/neuronal function (assessed by ABR wave I amplitude), and cognitive function (assessed by self-reported diagnosis of PTSD and/or performance on the Letter Number Sequencing Test) on complex speech perception. Subjective difficulty with speech understanding was assessed using the Speech, Spatial and Qualities of Hearing scale (SSQ-12), while speech perception performance was measured objectively using tests of speech in noise, time compressed speech, and spatial release from masking.

Results: Overall, no clear relationship was observed between average DPOAE levels or ABR wave I amplitude and complex speech perception. However, self-report of a PTSD diagnosis was associated with poorer complex speech perception ability, while better Letter Number Sequencing scores were associated with improved complex speech perception performance.

Conclusions: These findings indicate important cognitive effects on all speech perception outcomes examined and a negative relationship between PTSD and complex speech perception. However, contrary to our hypothesis, OHC and synaptic/neural function did not show a significant effect on complex speech perception ability. However, this finding could be a result of the limited OHC dysfunction in these "normal hearing" samples.

Poster # 49

Masking Release of Unvoiced Speech in Amplitude Modulated Noise
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Objectives: When naturally uttered speech is presented in AM noise compared to in steady-state noise, speech recognition often improves. This masking release effect could result from listening in the temporal dips of the masker where SNRs are much higher. It could also result from making use of the periodicity in the target speech (i.e. F0, harmonic structure). Unvoiced speech, however, is entirely noise-excited and contains no periodic structure. Therefore, recognizing unvoiced speech in modulated noise in theory should show little amount of masking release. Such assumption has been widely supported by literatures using noise vocoded speech with limited number of spectral channels as well as studies on speech in noise of cochlear implant users. But there were also a few literatures showing small amount of masking release for noise-excited speech in AM noise. The main purpose of the current study examines whether recognizing unvoiced speech in AM noise shows masking release. It is hypothesized that there is small amount of masking release for unvoiced speech in modulated masker, and the amount of masking release varies with modulation rate of the masker and the frequency composition of the speech.

Design: At the time of submission, 9 undergraduate and graduate students from the University of Pittsburgh participated. They all had normal tympanometry, normal DPOAE from 1 to 8 kHz and hearing threshold ,â§ 20 dB HL from 0.25 to 8 kHz. Fifteen more subjects will participate soon after the submission. The speech targets were IEEE sentences processed to sound unvoiced. The masker was speech-shaped noise with or without sinusoidal modulation. The modulation rates were 0, 4, 16 Hz for LPF speech and 0, 16, 32 Hz for HPF speech. Speech recognition threshold was measured through adaptive 1-down-1-up procedure. The speech was fixed at 65 dB SPL.

Results: The results showed a general trend that the SRT decreased with increasing modulation rates. The patterns of mean SRT change as function of modulation rates were strikingly similar for LP and HP filtered speech despite that the masker modulation rates were on average higher for the HPF than the LPF speech. However, there was no statistically significant main effect of modulation rate due to small sample size (at the time of submission) and large individual differences.

Conclusions: The current study showed that, contrary to traditional belief, lack of access to periodicity did not entirely abolish the benefit of masking release for speech understanding in AM noise. Despite the large individual differences, the amount of masking release seems to increase with increasing modulation rate of the masker. Meanwhile, HPF unvoiced speech requires more rapidly modulated noise than LPF speech to achieve same amount of masking release. It is possible that the inherent temporal window to process LPF and HPF speech is different and HPF speech requires more rapidly fluctuated noise to produce modulation masking. A clinical application is that when examining people with poorer temporal processing in a constrained frequency region, one may need to tailor the masker modulation rate to avoid listening ‘off-modulation-frequency’.

Poster # 50

SNR and Presentation Level effects on Three Listening Effort Measures
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Objectives: Implementing listening effort as a clinical measure can examine the top-down speech processing in addition to bottom-up processing examined by the audiological test battery. The selection of listening effort

measure is hindered by varying underlying constructs and unknown effectiveness and reliability. The main objective of this study is to compare the effectiveness and reliability of pupillometry, working memory and subjective rating scale - the physiological, behavioral, and subjective measures - at different signal to noise ratios (SNR) and presentation levels : when administered together. The effectiveness of these measures will be presented in this poster.The research questions are: (1) Is there an effect of SNR and PL on listening effort measures? (2) Is there an interaction between SNR and presentation level? (3) Which measure has the higher effect of SNR and presentation level? The three listening effort measures were expected to have different effect sizes because of different underlying constructs.

Design: Using a repeated measure design, we examined how SNR (+10 dB to -10 dB) and presentation level (50, 55, 65 dB SPL) affect listening effort. Five dependent measures were obtained for each condition - peak pupil dilation, working memory, speech recognition, and subjective rating (listening and recall effort). Tobii eye-tracker software and custom MATLAB programing were used for stimulus presentation and data analysis. Five young, normal-hearing, native English speakers were recruited for the pilot study. An a priori power analysis indicated a minimum of 14 subjects detect a medium effect at 0.05 alpha level with 0.8 power. It is anticipated that all data collection and analysis will be completed in time for the presentation.

Results: Separate two-way repeated measure ANOVAs were conducted for each dependent variable. Speech recognition scores reduced significantly with reduction in SNR, but there was no effect of presentation level. SNR significantly affected pupil dilation (Œ∑p2=.126; p<.05), working memory (Œ∑p2=.989; p<.05), and subjective rating scale (listening effort Œ∑p2=.925; p<.05); Presentation level significantly affected only pupil dilation (Œ∑p2=.161; p<.05) and subjective rating (listening effort Œ∑p2=.886; p<.05). The pupil dilation peaked at 0 dB SNR for 55 and 65 dB SPL and at -5 dB SNR for 50 dB SPL (interaction: Œ∑p2=.151; p<.05). The working memory and subjective rating increased with decrease in SNR for all presentation levels. The effort was least at 55 dB compared with 50 and 65 dB SPL.

Conclusions: The listening effort trend across SNRs agreed with previous studies. The presentation level effect on listening effort in the absence of speech recognition score differences was a new finding, but factors like small sample size, pupil baseline, speech material, loudness, and/or audibility can influence the presentation level effect. SNR had the highest effect on working memory followed by subjective rating and pupil dilation.Currently there are no standardized measures of listening effort for clinical use. This study provides a comparison of the listening effort tools and in future may facilitate appropriate tool selection for clinical use.

Poster # 51

Daily-Life Fatigue in Mild-to-Moderate Hearing Impairment: An EMA Study

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Objectives: Previous research has indicated an association between hearing impairment (HI) and fatigue, however the temporal and contextual correlates of such fatigue are largely unexplored. The present study used ecological momentary assessment (EMA) to determine (1) if people with HI are more fatigued than normal hearing (NH) individuals, (2) whether HI and NH individuals show similar levels and diurnal patterns fatigue, (3) whether people with HI spend less time in challenging listening situations compared to NH controls, and (4) whether more challenging listening situations are associated with more fatigue, and if hearing ability influences any observed association.

Design: Participants were 24 HI and 20 NH adults, aged 44-76 years (M = 65.4, SD = 7.5). Data were collected using smartphones and a commercially-available EMA app, which ran the specified EMA protocol for this study. Participants responded to six smartphone surveys per day for two weeks. 'In-the-moment' questions asked participants to report on their listening situation and to rate their current level of fatigue at random time-points throughout the day. Data were analysed using multilevel modelling.

Results: Hearing ability was unrelated to both trait ($t(42) = .28$, $p = .785$) and momentary fatigue ($t(42) = .72$, $p = .474$). Participants became increasingly fatigued throughout the day ($B = .12$, $t(2648.3)$, $p < .001$) at a similar rate for both groups ($B = .01$, $t(43.9) = .17$, $p = .866$). Challenging listening situations occurred infrequently both for HI and NH groups. NH participants were more likely to say that there were people speaking in the background who they were trying to ignore, but HI participants were more likely to perceive and report a greater number of background speakers. Finally, no associations were found between within-person listening activities/environments and momentary fatigue, and no interactions with hearing ability, but person mean listening activity ($F(1, 37.43) = 5.08$, $p = .030$) and conversational status ($F(1, 34.34) = 6.04$, $p = .019$) were related to momentary fatigue. Notably, having tinnitus was positively related to both mean momentary fatigue ($t(42) = -2.04$, $p = .048$) and individual momentary fatigue scores after controlling for other covariates ($t(43.74) = 2.94$, $p = .005$).

Conclusions: This is the first study to explore and compare fatigue across HI and NH groups using EMA. Contrary to expectations, the NH and HI groups showed similar levels and diurnal patterns of fatigue, and aspects of the listening environment were mostly unrelated to fatigue. Significant between-person differences suggest that people who spent more time in speech/listening situations and larger conversational groups tended to report higher levels of momentary fatigue. However, in the absence of within-person effects, these findings must be accepted cautiously. Issues with the measurement of fatigue and perceived hearing-related difficulties among NH participants are notable limitations of the study. Further research is warranted, particularly with more severely hearing-impaired participants.

Poster # 52

Cognitive Influences on Band Importance Functions in Children

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Objectives: Band importance functions are used to determine which frequencies people rely on most in order to understand speech stimuli. Previous research indicated an age effect for band importance functions of pediatric participants and high variability among children who are the same age. However, previous research utilized stimuli with varying amounts of linguistic context. It is unclear if the age-related differences in band importance can be attributed to linguistic context; as children age and develop language over time, they may become less reliant on broadband acoustic-phonetic cues and more reliant on linguistic context so that band importance functions more closely approximate those of adults.The goal of this study was to determine: 1. Does band importance function shape change based on the linguistic context of the stimuli? 2. Do children’s cognition, selective attention abilities, language skills, and age contribute to variability in band importance function weighting? 3. Do children’s band importance functions contribute to speech understanding in noise? The following hypotheses were proposed: 1. Use of word stimuli will produce sharper band importance functions, where one or more bands contributes more to speech understanding than others. Use of nonword stimuli will yield flatter band importance functions, where all bands contribute equally. 2. Children with better cognitive,

selective attention, and language skills and older children will produce sharper band importance functions. 3. Children with sharper band importance functions will have better speech in noise abilities.

Design: Forty typically developing children with normal hearing between six and 12 years participated in this study. Participants were chosen from the Boys Town National Research Hospital Human Research Subjects Core database. All participants' hearing thresholds were obtained from 250-8000 Hz bilaterally. Out of six frequency bands, three were randomly presented and the participant's response was scored as correct or incorrect. A regression analysis determined the probability of a correct response when a specific band was present. Stimuli for the band importance task included recorded monosyllabic words and nonwords. A total of 288 presentations per condition were administered to each participant. An adaptive speech recognition task using Pediatric Arizona Biomedical Institute sentences presented in speech-shaped noise was used to measure of speech-in-noise abilities (SNR50). Receptive and expressive vocabulary skills were assessed using the Peabody Picture Vocabulary Test Fifth Edition and the vocabulary subtest of the Weschler Abbreviated Scale of Intelligence, Second Edition (WASI-II). Nonverbal intelligence was assessed using the matrix reasoning subtest of WASI-II. Selective attention was assessed using the Flanker and Switcher tasks from the Psychology Experiment Building Language.

Results: Preliminary analyses demonstrated that the band importance function weights for 0.5 and 2 kHz were significantly higher for the word condition than the nonword condition. Selective attention abilities were predictive of the weighting at 0.5 and 2 kHz regardless of stimulus type.

Conclusions: Hypothesis one is supported by preliminary data. Of the predictions in hypothesis two, the data only supports the impact of selective attention abilities thus far. Hypothesis three is currently not supported by the collected data. More data will be analyzed to further explore the aforementioned hypotheses.

Poster # 53

An Absorbance Peak Template for Assessment of Newborn Conductive Pathways

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Objectives: Conductive dysfunction at birth is associated with high false-positive fail rates on hearing screening tests. Power absorbance is a wideband acoustic immittance (WAI) measure that is sensitive to conductive dysfunction in newborn ears. Often, absorbance normative range is computed in a sample of normal-hearing participants at every frequency, resulting in loss of subtle absorbance-frequency information. Also, this approach results in large variability in normal measurements, which limits absorbance test performance. We hypothesize that an alternative normative approach that characterizes absorbance and frequency of the principal absorbance peak will improve test performance and simplify the interpretation of individual measurements. The overall goal of this preliminary investigation is to develop and validate a template for normal absorbance peaks, and to assess its performance in comparison to the traditional normative range approach.

Design: An absorbance peak template was computed in a training data set including repeated measurements from 98 newborn ears that passed the hearing screenings. In each measurement, absorbance and frequency of the principal peak, (identified between 750-4000 Hz) were determined. The 5th to 95th percentile of peak absorbance and peak frequency defined the bounds of the peak template. For comparison, the traditional normative 10th-90th-percentile absorbance range was computed at each frequency. The peak template and normative range methods were tested in a separate data set for validation (from Sanford et al., 2009), which

included ears that passed (n=359) and failed (n=64) the hearing screening. Receiver operator characteristic (ROC) tests assessed the performance of the absorbance peak variables (peak absorbance, peak frequency, and multivariate combination of both) in the prediction of hearing screening outcomes. As well, their performances were compared to that of absorbance averages over multiple frequency intervals. Classification matrices for the peak template and the traditional normative range compared the two methods. Furthermore, the interpretive framework provided by the absorbance peak template was assessed.

Results: The area under the ROC curve (AUC) was higher for absorbance peak, AUC=0.83, compared to peak frequency, AUC=0.64. Multivariate analyses indicated no significant contribution of peak frequency, and the multivariate score AUC=0.83. By comparison, the best performing absorbance-averaged band (1000-2000 Hz) had an AUC=0.82, which is similar to peak absorbance. The sensitivity and specificity of peak absorbance using the template were 87% and 61%, compared to 80% and 67% with the traditional normative range method. Using the template, absorbance peaks were categorized as follows: Normal absorbance and normal frequency; Abnormal absorbance and normal frequency; Normal absorbance and abnormal frequency; Abnormal absorbance and abnormal frequency. Specific cases highlight the clinical interpretive potential of these categories.

Conclusions: The newly developed absorbance peak template predicts the outcomes of newborn hearing screening with similar test performance to the conventionally employed normative range approach. Specifically, the size of the principal absorbance peak, regardless of its frequency, can be used to assess the status of the conductive pathway at birth. Pending further research, the template provides an interpretive framework for absorbance peak characteristics that maybe useful for assessing more subtle changes in the resonant properties of the conductive pathway.

Poster # 54

Effect of Amplification on Psychophysical Tuning Curves

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Objectives: Spectral resolution is the ability to resolve frequency components of a sound and this ability is required for decoding speech. Although adults with hearing loss have poorer spectral resolution than adults with normal hearing, it is unclear the extent to which increasing audibility with amplification changes access to spectral information. As such, this study aimed to quantify the effects of partially restoring audibility -though amplification - on access to spectral cues. Two prescriptive procedures, Desired Sensation Level-adult and child (DSL-A, DSL-C) were used due to their differences in prescribed audibility. The first hypothesis was that increasing audibility for listeners with sensorineural hearing loss (SNHL) will improve access to spectral information. The second hypothesis was that because DSL-C will restore audibility more than DSL-A, DSL-C will provide listeners with hearing loss more access to spectral cues than DSL-A.

Design: There were 26 participants with SNHL and ten participants with normal hearing (NH). Spectral resolution was measured using psychophysical tuning curves (PTCs). Participants with NH were tested unaided. Participants with SNHL were tested under 3 processing conditions (unaided, DSL-A, DSL-C). A hearing aid simulator implemented in MATLAB was used to amplify stimuli for the DSL-A and DSL-C conditions. Threshold for a 2-kHz target was obtained in quiet and in the presence of 7 pure-tone maskers ranging from 1 kHz to 3.2 kHz.

Results: A series of repeated-measures ANOVA were used to determine the effects of masker frequency, processing condition, and hearing status on the amount of masking. For the participants with SNHL, there was a significant main effect of amplification ($p=.002$), due to the amount of masking being greatest with DSL-C and least for the unaided condition. There was also a significant main effect of masker frequency ($p<.001$), due to the amount of masking increasing as masker frequency became more remote from the target frequency. There was also a significant two-way interaction of amplification condition with masker frequency ($p<.001$), due to the amount of masking, relative to the unaided condition, being greater with DSL-A and DSL-C for the two lowest masker frequencies. For the other frequencies, the amount of masking did not differ significantly by processing condition. Although amplification improved the low-frequency side of the PTC, tuning was still significantly greater for the participants with NH.

Conclusions: This study found that relative to the unaided condition, the amount of low-frequency masking increased significantly with both DSL-C and DSL-A. Masking for the high-frequency side of the PTC did not change. There was not a significant difference in the PTCs between DSL-A and DSL-C. Thus, these findings support the first hypothesis, that increasing audibility with amplification will improve access to spectral cues but not the second hypothesis, that increased audibility with DSL-C relative to DSL-A will improve access to spectral cues. These results suggest that increasing audibility with hearing-aid amplification can improve access to spectral cues, but that further increases in audibility are not beneficial.

Poster # 55

The Size of Long Auditory Scenes

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Objectives: Past research has shown that the size of the auditory scene is small for scenes consisting of sources of nearly-simultaneously presented short sounds (e.g., scenes of 3-5 words are not perceptually different than scenes than have many more words). This research has also shown that for scenes of three or more short sounds spatial separation of the sound sources has little effect on the perceived size of the auditory scene. This paper describes the perception of 5-second long, sentence-length auditory scenes.

Design: Scenes of 2, 4, or 6, 5-s long sentences were presented and a target sentence was added to this background. Normal-hearing listeners responded when they perceived the added target sentence. In addition to the number of background sentences, the gender of the background and target talkers, the spatial separation of the talkers, and the time at which the target was added were manipulated.

Results: When listeners were provided maximal information about the task, they were able to indicate when the target sentences were added to backgrounds of several talkers with high accuracy and short response latency. When listeners had less information about the task, their accuracy dropped to near chance with 4 to 6 background sounds, response latencies increased substantially, and spatial separation of the talkers made little difference.

Conclusions: As for short duration scenes, auditory scenes of longer duration are also perceptually small (fewer than 4-6 sound sources), and often spatial separation of the sound sources in the scene does not affect perceptual performance. However, for long auditory scenes, listeners can take advantage of information provided to them about the scene to perceptually process a larger number of sound sources. One consequence of perceptually small auditory scenes is that devices (e.g., virtual audio, hearing aids, cochlear implants) may not have to process a large number of sound sources to replicate normal hearing performance.

Poster # 56

The Association Between Acoustic Reflexes and DPOAEs in Young Adults
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Objectives: The role of the acoustic reflex has been shown to act as a protective mechanism, stiffening the ossicular chain to prevent distortion and damage caused by high intensity low frequency sounds. Distortion product otoacoustic emissions, on the other hand, are a sub-clinical way to measure cochlear function and see potential damage that has already been inflicted. The purpose of this study was to evaluate the association between acoustic reflexes and distortion product otoacoustic emissions (DPOAEs) in young adults with normal hearing.

Design: Twenty-six young adults, 18 women and 8 men participated. A survey was administered that included self-reported personal music (PM) system use with earphones. Otoscopy and tympanometry were completed as well as 1 kHz ipsilateral acoustic reflex thresholds (ART). For ARTs, presentation level began at 85 dB HL and was increased in 5-dB steps until a repeatable 0.02 mmhos negative deflection was measured. The participant was then seated in a double-walled, sound-treated room for DPOAE testing. DPOAE data were obtained using f2 frequencies of 1-6 kHz using stimulus tones (L1,L2 = 55,40 dB SPL,f2 /f1 =1.22; f2 > f1) swept in frequency at 8 sec/octave. DPOAE data were averaged into third-octave bands (1, 1.5, 2, 3, 4, and 5 kHz) and considered present > -20 dB SPL and at a +6 dB signal-to-noise ratio. DPOAEs were measured before and after participants listened to one hour of music through their personal earphones. A probe microphone (placed within 5 mm of the tympanic membrane) was used to measure the continuous level of music within the ear canal averaged over one hour.

Results: Across all f2 frequencies, those with higher ipsilateral acoustic reflex thresholds had more of a decrease in DPOAEs after one hour of music. In one regression model, ART alone was a significant predictor of change in DPOAEs after music, accounting for approximately 6% of the variability. Those who reported higher PM system volume use had higher, but not statistically significant, ARTs than those who reported lower PM system volume use. When both self-reported volume use and listening level were included in regression models, separately, ARTs were still significant predictors of change in DPOAEs.

Conclusions: In this sample of young adults with normal hearing and measurable ARTs, those with higher ARTs had more of a decrease in DPOAEs after listening to one hour of music through earphones. After accounting for self-reported PM system volume use and listening level during one hour, ARTs were significant predictors of changes in DPOAEs. These data suggest the importance of obtaining ART data to determine whether or not young adults may be vulnerable to recreational noise exposure.

Poster # 57

Objective and Behavioral Indices of Linguistic/Phonetic Similarity in Informational Masking
Christopher Edward Niemczak, AuD; Kathy Vander Werff, PhD, Syracuse University, Syracuse, NY

Objectives: Understanding speech in a background of other people talking is one of the most difficult listening challenges for hearing-impaired individuals, and even for those with normal hearing. Speech-on-speech

masking is known to contribute an informational masking effect, or increased perceptual difficulty over non-speech noise. Similarity between target and masker speech is known to be one definitive factor contributing to the amount of perceived informational masking. Although many aspects of acoustic similarity have been well studied, less is known about the effects of similarity in the linguistic and phonetic content of the target and masker. The objective of this study was to determine whether informational maskers with a proposed hierarchy of linguistic/phonetic similarity impacted both objective neural representation and behavioral word recognition of target words in the native language of the listener.

Design: A repeated measures paradigm was used, with 4 levels of 2-talker masker conditions (temporally and spectrally matched) representing hypothesized increasing levels of informational masking: (1) No masker (quiet), (2) Mandarin (linguistically and phonetically dissimilar), (3) Dutch (linguistically dissimilar, but phonetically similar), and (4) English (linguistically and phonetically similar). English word stimuli (/bat/ and /pat/) were presented in an oddball paradigm in each masker condition at +3 dB SNR, and responses recorded simultaneously for P1-N1-P2 (frequent waveform) and P3 (infrequent waveform). Analyzed outcomes included peak amplitude and latency of early sensory (N1) and late cognitive levels (P3) of auditory processing. Behavioral words-in-noise performance was measured (NU-6 25-word lists) at 0 dB SNR.

Results: Complete data have been obtained from 14 participants, with data collection ongoing. Preliminary statistical analyses using repeated measures ANOVA indicate that N1 and P3 responses in quiet were significantly larger in amplitude and earlier in latency compared to all noise conditions (p<0.05). N1 amplitudes were smallest for the English masker condition compared to the other language conditions, but did not differ significantly between Dutch and Mandarin conditions. P3 for the English masker condition was also the smallest of the noise conditions, but also no significantly difference was found between Dutch and Mandarin. There were no significant latency differences among responses across language masker conditions for either N1 or P3. Behavioral words-in-noise scores were significantly poorer for English compared to either Dutch or Mandarin maskers, but did not differ between Mandarin and Dutch maskers. Full statistical analyses will be reported.

Conclusions: Objective and behavioral outcomes of the effects of varying linguistic and phonetic similarity between target and masker are consistent with three primary conclusions. First, a native language masker that is linguistically and phonetically similar to the target result in the largest reduction in AEP amplitudes and word recognition performance, presumably due to higher levels of informational masking. Second, non-native language maskers had less impact on amplitudes and word discrimination scores, but the distinction between linguistically and phonetically similar vs. dissimilar did not appear to significantly affect either. Finally, similar results were seen at both sensory pre-attentive and cognitive post-attentive levels of processing as indicated by N1 and P3 AEPs.

Poster # 58

Artificial Intelligence Based Applications on Wideband Acoustic Immittance Data

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Objectives: Objective: Investigate the application of artificial intelligence (machine learning) based techniques for subject characteristics prediction from wideband acoustic immittance (WAI) measurements.

Design: Data: WAI measurement data were obtained from the publicly available normative WAI database comprised of subject characteristics and corresponding WAI measurements for each subject. The database contained data from 12 independent studies. Experiment: Artificial intelligence techniques like convolution neural networks (deep learning), k-nearest neighbor clustering and artificial neural nets were trained on the absorbance distributions values from the WAI measurements. Given the limited number of samples / subjects in each study, a leave one out approach was adopted to evaluate the performance of the trained classifiers. The accuracy of the classifiers in classifying each class for a given subject characteristic was used for quantitative analysis. For non-binary subject characteristics like 'age', the median value of the ages in a given study was used to group the subjects into two bins for classification purposes. The experiments were performed for each study independently and on the combination of all the studies in the WAI database (excluding voss1994 and lewis2015 studies). The results of the experiments were compared to the existing priors (baseline accuracy) for each study.

Results: The performance of the machine learning algorithms showed a substantial gain over random guessing baseline. For classifying subject characteristic 'age' – the classifier trained on the data from all studies had an accuracy of 71.2% compared to the baseline accuracy of 61.5%. Additionally, in the independent analysis of the Voss2010 study, the trained classifier had a higher accuracy of 96.7% compared to the baseline accuracy of 66.7% and for the Abur2014, the trained classifier had a superior accuracy of 97.3% compared to the baseline accuracy of 65.3%. Lower accuracy on the combined studies results and specific independent study results, as compared to accuracy on Voss2010 and Abur2014 studies, may be attributed to the insufficient amounts of data samples and corresponding variability within samples, as required by majority of the applied machine learning techniques for robustness and higher accuracy classifiers.

Conclusions: This study shows the feasibility and performance of applying artificial intelligence techniques for subject characteristic prediction using WAI measurements. The results for the subject characteristic 'age' show that with limited amount of available data the classifiers were able to attain higher accuracy than the baseline. The results also demonstrate the applicability and feasibility of using machine learning techniques on WAI data for subject characteristic prediction, and potential predictions for disease diagnosis. The experimental results also indicate that such techniques can be made more powerful and accurate with the usage of increased amounts of respective WAI data as required by many of the machine learning classifiers.

Poster # 59

Modifying the Spectral Correlation Index for Use with Envelope-Distorted Speech

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Objectives: The goal of this project was to explore the use of a metric of auditory signal change: the spectral correlation index. This measure was originally proposed for use with hearing-aid processed speech, and quantifies changes in amplitude modulation within each carrier band between input and output signals. Here, the spectral correlation index is extended to multiple envelope distortions that model effects that may occur in realistic listening. It is also modified to consider carrier frequency importance for overall speech recognition. Theoretically, weighting carrier frequency bands by their importance for conveying speech information will result in a metric that more fully captures variance in speech recognition. This project seeks to explore the results of adding importance weighting to the spectral correlation index.

Design: The spectral correlation index and the modified version of the spectral correlation index are retrospectively applied to large datasets of hearing-aid processed speech and recognition of those signals by listeners with hearing loss. In each case, test signals were low-context sentences in multitalker babble and/or reverberation and hearing aid processing was applied via off-line simulations. Listeners were adults with mild-to-moderate sensorineural hearing loss and responded by repeating the presented sentence. Speech recognition was quantified as number of correctly repeated key words.

Results: Preliminary results show that the importance-weighted spectral correlation index may be more appropriate than the unweighted spectral correlation index for studying the relationship between envelope distortion and speech recognition.

Conclusions: The importance-weighted spectral correlation index is consistent with auditory perceptual models and thus is recommended over the unweighted spectral correlation index for predicting variance in speech recognition.

Poster # 60

Peripheral and Central Auditory Comparisons Between Adolescents and Young/Middle-Aged Adults
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Objectives: While considerable attention has been devoted to understanding maturational processes in early childhood and degenerative process due to advancing age in the elderly, there has been relatively little focus on peripheral and central auditory changes between adolescent and middle adult age groups. Adolescents are at high risk for both recreational noise-exposure and concussion, both of which may impact affect peripheral and central auditory function. In addition, adolescence is a dynamic period of brain development, and both cognitive task performance and auditory evoked potentials are known to have long developmental time courses. Impairments in hearing and auditory processing may have a substantial impact, given high academic demands and increasing reliance on learning through auditory modalities for this group. It is therefore important to define relationships among peripheral and central auditory factors specific to typical adolescents and the influence of late maturation and early degenerative age-related auditory changes in the peripheral and central auditory system. Ultimately this knowledge can be applied to study the impacts of noise exposure, concussion, and other hearing-related risks on the adolescent age group.

Design: This study is a cross-sectional design utilizing objective and behavioral measures of peripheral and central auditory function across age groups including adolescents (13-19 years), young adults (20-40) and middle-aged adults (40-60). Pure tone audiometric thresholds (standard and extended high-frequencies), distortion-product otoacoustic emissions (DPOAEs), middle ear measures (tympanometry and wideband reflectance), uncomfortable loudness levels, speech-in-noise performance (QuickSIN), auditory brainstem responses (ABR), and cortical auditory evoked potentials (CAEPs) were obtained from the right ear for all participants. Noise exposure history was also evaluated using the Noise Exposure Questionnaire (NEQ). ABRs were obtained for high-level clicks using tiptrodes and CAEPs were recorded to /ba/ syllables in quiet and in multi-talker babble.

Results: Thirty-six individuals have completed testing to date and enrollment is ongoing. Preliminary data analyses indicated that many of the outcome measures, particularly those relating to peripheral auditory status) were significantly different between the adolescent group and the older middle-aged group (40-60). In addition,

significant group differences were observed between the adolescent group and the younger adult group (20-40) for several of the outcome measures including high-frequency thresholds, uncomfortable loudness levels, ABR inter-peak latencies, and CAEP amplitudes and latencies in babble. Significant age-related correlations across were also observed for pure tone thresholds (all frequencies), DPOAE signal-to-noise ratios, wideband reflectance (mid-frequency range), ABR latencies (wave I, III) and ABR amplitudes (wave I) across the adolescent to middle-age time period.

Conclusions: Auditory outcomes in adolescents aged 13-19 show significant differences compared to adults in young to middle adulthood. Age-related changes were observed for many of the peripheral audiometric measures, and were also observed in the preliminary analysis for brainstem and central auditory measures. Given these age-related changes in peripheral and central status, consideration of age-related normal/abnormal outcomes for evaluating hearing and central auditory performance in adolescents should be considered for clinical and research purposes. Relationships among measures of peripheral status and central auditory outcomes across age and the history of self-reported noise exposure will also be discussed.

Poster # 61

Utility of DPOAE Measures in Individuals with Normal Behavioral Thresholds

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Objectives: Distortion product otoacoustic emissions (DPOAEs) have the potential to reflect cochlear damage that has not yet been observed in the audiogram. It is expected that those with a normal audiogram should have present DPOAEs. However, it is possible that some individuals without impaired cochlear function may not have present DPOAEs. The purpose of this study is to determine what percentage of those with normal hearing thresholds have DPOAEs at frequencies up to 8 kHz. To fully explore the clinical utility of DPOAEs, factors such as sex, age, ear, and stimulus level were examined. It is hypothesized that these factors will result in higher DPOAE percentages in females, younger ears, and higher stimulus levels.

Design: Two hundred and twenty one females and one hundred and thirty one males ranging in age from 10 to 65 years with normal hearing thresholds (<20 dB HL through 4 kHz) were evaluated. Five age categories were defined: 10-21, 22-35, 36-45, 46-55, and 56-65 years. Measurements were made monaurally (ear chosen at random). DPOAEs were elicited at f2 frequencies of 1 through 8 kHz with a stimulus ratio (f2/f1) of 1.22 and three stimulus level (L1/L2) combinations, low, mid, and high (55/40, 65/50, 75/75 dB SPL, respectively). A depth-compensated calibration procedure was utilized.

Results: Overall, the percentage with DPOAEs increased as stimulus levels increased. For the low and mid stimulus level combinations, DPOAE percentage increased as frequency decreased. At low stimulus levels, females had a higher percentage of DPOAEs at all frequencies tested compared to males. At mid and high stimulus levels the percentages were similar among males and females through 3 kHz, while females had higher percentages than males at frequencies >4 kHz. For low stimulus levels the percentages with DPOAEs were similar across age groups at 1 and 1.5 kHz and as frequency increased the separation among the age groups increased with the oldest individuals exhibiting the fewest DPOAEs. As stimulus levels increased, the percentage of DPOAEs was similar for all age groups through 4 kHz (mid level) and 6 kHz (high level). Similar percentages were measured for right and left ears. DPOAE levels ranged from –19 to 25 dB SPL with corresponding noise floor values of –66 to 8.9 dB SPL.

Conclusions: At mid and high stimulus levels from 1-4 kHz, approximately 98% of the population examined have measurable DPOAEs. This percentage decreases at frequencies greater than 4 kHz and for low stimulus levels and is affected differently dependent on sex and age. Clinically, it is important to realize how sex, age, stimulus levels, and frequency affect the potential to measure a DPOAE in the presence of normal behavioral thresholds.

Poster # 62

Hearing Loss and Amplification Effects on Single and Multisource Localization

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Objectives: Hearing loss degrades sound localization for short and long stimuli. Head movement during localization tasks, however, improves localization for ongoing stimuli. This study expanded upon previous research to examine the effects of hearing loss and amplification devices on sound localization. Two experiments examined the effects of length and number of stimuli. Our hypothesis was that hearing loss would degrade localization of both short and ongoing stimuli; and that hearing aids would degrade localization of short stimuli but not ongoing stimuli that allow head movements.

Design: Adults with normal hearing (25) and adults with hearing loss (15) that wear bilateral hearing aids participated in single-source and multi-talker localization tasks. All hearing aids were verified to match prescriptive targets. Participants with moderately severe or worse hearing loss were tested with one and both hearing aids while participants with mild to moderate hearing loss were tested with and without hearing aids. Participants with normal hearing were tested with and without bilateral low-gain receiver-in-the-ear (RITE) hearing aids to examine their effects on sound localization. Participants also completed a short form of the Speech Spatial and Qualities of Hearing Scale (SSQ12). Stimuli were roved between 54-68 dB SPL and presented from a 360 degree eight-speaker array with speakers at 45 degrees azimuth intervals. Short, single-source localization presented a 250ms white-noise for each trial with participants always facing forward. Participants completed 160 trials in each device condition in blocks of 40 trials with the speaker randomized across trials. The multi-talker localization test presented speech of one to five talkers from randomly determined speakers. Participants sat in a swivel chair and could turn their head and spin in the chair to locate the active loudspeakers. Participants were given 15 seconds per trial to determine how many talkers were present and their locations and responded with a stylus on the touch screen in front of them. Participants completed 80 trials for each device condition in blocks of 20 trials. Following both tasks, participants answered questions regarding the realistic properties of the task and the effects of wearing hearing aids during the task.

Results: Preliminary results indicated that hearing loss had a significant impact on localization, although some hearing aid listeners were at the ceiling for localization of a single ongoing talker with and without hearing aids and hearing aid listeners reported no localization difficulty on the SSQ12. As hypothesized, results indicated that hearing aids improved the response time and accuracy of multi-talker localization of individuals with hearing loss. However, amplification degraded localization for short stimuli. Listeners with moderately severe to severe hearing losses performed significantly better with both hearing aids than one hearing aid; while those with mild to moderate hearing losses received less benefit from hearing aids.

Conclusions: These results indicate that head movements during ongoing stimuli may allow listeners to overcome some of the sound localization degradation caused by hearing aids. These results suggest that spatial hearing and sound localization experiments examining the effects of hearing aids must be carefully designed to reflect the benefits or detriments of hearing loss and amplification devices.

Poster # 63

Auditory Implications of Sound Exposure: A View Through Efferent System

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Objectives: Subtle and early damage to the auditory system from noise exposure is unlikely to be detected by the current clinical screening procedures. Current efforts, based primarily, on testing the afferent pathway have not produced conclusive results. In contrast, the subclinical noise-induced damage has been found to be associated with the pathophysiological changes in the efferent system. Specifically, a threshold elevation of the middle ear muscle reflex (MEMR) and hyperactivity in the medial olivocochlear reflex (MOCR) have been reported in noise-exposed animals. In humans, similar changes in the efferent system have been reported to be correlated with noise-induced tinnitus and noise overexposure in humans. This opens the possibility of utilizing the reflex metrics to investigate the effects of noise exposure. Here we used an innovative click-based test of efferents that minimizes the limitations in the conventional methods to examine the effects of noise exposure on the MEMR and the MOCR. We hypothesized that elevated MEMR thresholds and a hyperactive MOCR will indicate a history of extensive noise exposure. The goal of this study is to develop a composite "damage score" based on the efferent functioning in individuals with clinically normal hearing.

Design: We evaluated cochlear, the MOCR, and the MEMR functioning in 4 (prospective 20) musicians and 5 (prospective 20) non-musicians between 18-35 of age with clinically normal hearing. Musicians were included because they were assumed to be exposed to high levels of noise on a daily basis but yet show clinically normal hearing. Questionnaires of noise exposure history and noise dosimetry were used to determine life-time noise exposure and daily noise dose, respectively. CEOAEs and the MOCR were concurrently measured with the MEMR activation being monitored using clicks (rate=62.5 Hz; 80-95 dB peak-to-peak SPL). We also evaluated two sensitive physiological markers for noise exposure including the stimulus-frequency OAEs and hearing thresholds at audiometric and extended-high frequencies (0.5-20 kHz). Additionally, we measured broad bandwidth ABR with clicks (bandwidth=0.8-16 kHz; rate=11.1 Hz) and speech intelligibility using the coordinate response measure sentences in speech-shaped noise (-16 to 0 dB SNR).

Results: Data has been acquired from nine participants (four musicians) thus far. Preliminary results from individual tests suggest that our efferent test reliably tracks CEOAEs, the MOCR, and the MEMR. Musicians appeared to have a lower cut-off for extended high frequency hearing thresholds. With additional data collection, we will (i) determine differential performance of groups in the efferent functioning, (ii) develop a damage score based on the efferent functioning, (iii) test the predictive validity of the damage score by comparing its performance against that of the sensitive physiological markers.

Conclusions: Our data will indicate (i) whether musicians are at risk of noise-induced damage, (ii) whether a composite MOCR/MEMR damage score can be reliably used to detect subtle changes in auditory physiology. The outcome of this study will lead to a rapid hearing screening tool.

Poster # 64

Methodological Improvements in Auditory Efferent Measurements

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Objectives: The role of the auditory efferent system, especially the medial olivocochlear reflex (MOCR), has been extensively studied. Yet, its functional relevance in human hearing is not well established. This is in part because, unlike in animal models, the MOCR activity is indirectly derived by measuring a change in otoacoustic emissions (OAEs). These methods suffer from several limitations: (1) test-parameters vary widely across studies, and as such, different stimulus levels result in different results, (2) subject to probe-drifts, (3) low signal-to-noise ratio (SNR) criterion, (4) when high SNR is enforced, measurement times are too long, (5) typically, only ear can be tested, (6) contamination by middle ear muscle reflex activation. While no one method can directly solve all these limitations, we propose improvements that address many of these issues: (1) derive the MOCR growth function as opposed to using a single level, (2) use probe stabilization methods (e.g., putty), (3) use high SNR (>12 dB), (4) we have tested methodological and signal processing improvements in this study, (5) we propose a novel bilateral stimulation technique, and (6) use a MEMR detection test. We predict that using these methodological improvements will lead to more reliable MOCR measurements. The objective of this study is to develop and test methodological improvements and signal processing strategies that improve the MOCR and the MEMR detection while minimizing measurement time.

Design: Data were acquired from 20 young normal-hearing adults (18-35 years). Clicks-trains, 62.5 Hz and 1s long, simultaneously and bilaterally evoked CEOAEs, and tracked the MOCR magnitude and time-course. Each trial consisted of 63 clicks repeated 335 times. Click levels ranged from 65-98 dB peak-to-peak (pp)SPL (6 dB intervals). The MOCR was estimated using two steps: first, CEOAEs from all the trials were averaged and considered in the time-frequency domain. Next, regions of interest (ROI) were selected based on (1) >12 dB SNR, (2) human cochlear delays, and (3) highest magnitudes in contour maps. The ROI was then applied across time to estimate the MOCR using an exponential line-fit. The presence of MEMR was assessed by comparing the incident and reflected portions of the click-stimulus using forward pressure level calibration. Because it is only the reflected portion of the click is influenced by the MEMR activation, comparison of the incident/reflected click ratio yielded wideband the MEMR activation across time.

Results: Preliminary analysis shows that CEOAE method and signal processing strategies significantly improve the speed of the MOCR detection, reducing the measurement time from ~8.5 to ~1.5 mins (67 trials). The incident vs. reflected sound detected greater MEMR activations at higher levels suggesting that the detections are likely true. Further analysis will validate these activations against reflex thresholds estimated in a tympanometer.

Conclusions: CEOAE-based signal processing strategies have the potential to expedite the novel MOCR paradigm and the comparison of incident vs. reflected stimulus pressure across time is a useful metric in determining wide-band MEMR. Using these techniques in future studies will improve confidence in the resulting MOCR estimate.

HEARING TECHNOLOGY / AMPLIFICATION

Poster # 65

The Effect of Compression in Hearing Aids on Localization Ability

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Objectives: Localization is one's ability to tell where sound is coming from in space. Adults with sensorineural hearing loss (SNHL) typically exhibit poorer localization than adults with normal hearing (NH)- possibly due to the loss of cochlear compression. Hearing aids with compression amplification are the most common rehabilitative device for adults with SNHL, yet there is a debate about the efficacy of compression amplification on localization. We hypothesized that a patient's ability to accurately perceive interaural level difference cues is dependent on the speed of the compression amplification programmed into the hearing aids. This hypothesis was formulated on the observation that cochlear compression is known to underlie the perception of interaural level difference (ILD) cues for listeners with NH and SNHL. If this hypothesis is found to be true, such a finding would have implications for (a) interpreting previous studies that examined the effect of compression amplification on localization and (b) rehabilitation of individuals with SNHL. Previous research indicates that there is a negative effect on ILD perception when compression is introduced, however those studies utilized the same compression ratio between patients. Our study calculated the compression ratio based on each participant's personal audiogram.

Design: 13 adults aged 65-83 (mean 71.5) years bilateral SNHL were recruited. Participants were tested under 3 compression conditions (fast, slow, unaided) and 2 ILD conditions (0 ILD and 7 ILD) for a total of 6 conditions. Each trial was run at least twice, with a third trial if the average of the first two was less than 1.4 times the less accurate run. How much compression speed affected participant's ability to complete the localization task was tested by measuring their ability to accurately perceive ILD cues between ears. The experimental task was done under headphones using a HA simulator and utilizing the DSL prescriptive procedure. Data was analyzed using a single ANOVA with compression speed as a factor.

Results: This hypothesis was tested by manipulating the extent to which compression speed effects ILD perception in adults with SNHL. It was observed that thresholds did not significantly change when compression amplification was set to different speeds- not supporting the hypothesis. The work presented here suggests that, within the parameters used for this study, compression speed does not significantly alter one's ability to perceive changes in ILDs. Previous research is in agreement with these results. We also found that there is a significant improvement on the localization task when in the unaided condition than when compression was introduced into the HA simulator.

Conclusions: This study concludes that compression speed does not significantly impact HA user's perception of interaural level difference cues and as such does not have a significant impact on the localization task. Unaided vs compressive settings did have a significant effect on ILD perception and may imply that not adding compressive amplification is the best option to strengthen ILD perception in SNHL listeners. One limitation includes the sensation level (SL) not being equated among participants, though all participants were able to hear the stimuli (SL ranged from 9-14 dB).

Poster # 66

Better Understanding of Hearing Protection Effects

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Objectives: Although hearing protection devices have originally designated to use for industrial workers or military solders for protecting their hearing against noise exposure, some people who recommended the hearing protection devices are frequently reluctant or even not worn due to uncomfortable and tight feeling. Over the century, many studies have been published for functions and effects of the hearing protection devices. However, these studies have brought the problem of how to organize and summarize their different findings, consequently resulting in suggestion of a systematic analysis considered as the highest level of evidence. The purpose of the present study was to evaluate functions and effects of the hearing protection devices while using a technique of the systematic review and meta-analysis.

Design: As the first approach, a total of seven electronic databases were checked from January 2000 to the October 2019 with related key terms such as 'hearing protection devices' and 'hearing protectors'. While checking our PICOS (i.e., participants, intervention, controls, outcomes, and study designs) inclusion criteria, 2,742 articles were classified into four sequent steps - identification, screening, eligibility, included. Then, a total of 20 studies were applied for the systematic review and meta-analysis. The effect size on the effects of hearing protection devices was calculated based on the standardized mean differences and 95% confidence interval. The summary estimating was examined by the random-effect model. Heterogeneity of the studies was identified using Higgins I2-statistics and Cochran's Q-test. Also, publication bias was checked by using funnel plot and Egger's regression test. If the results of meta-analysis showed a high heterogeneity, the sub-group analysis which included three sub-groups based on the characteristics and effects of hearing protection devices (i.e., attenuation, sound localization, and speech intelligibility) was considered as the further step.

Results: Using chi-square test, scores of the study quality showed that there was no significant difference between scores of the study quality (œá2 = 3.7536, df = 19, p > 0.05). In terms of the functions and effects of the hearing protection devices, sound localization showed relatively higher effect size (0.3980, 95% confidence interval: -0.0912 - 0.8873) than that of speech intelligibility (0.2238, 95% confidence interval: -0.3732 - 0.8208) and that of sound attenuation (-0.0041, 95% confidence interval: -1.5064 - 1.4981). The results of Egger's regression test and funnel plot provided that the sound attenuation (p = 0.4066), sound localization (p = 0.9824), and speech intelligibility (p = 0.8051) had the publication bias. The sound localization and speech intelligibility showed low and moderate heterogeneity (I2 = 0 and 69.9%, respectively), whereas the attenuation had high heterogeneity (I2 = 96.7%).

Conclusions: Our results demonstrate that the hearing protection devices might attenuate the incoming sounds as originally designated purpose although the overall effect sizes of three sub-groups were small. However, they degrade listener's sound localization and speech intelligibility at the same time, which means that the researchers and clinicians should consider potential pros and cons when the hearing protection devices being recommended.

Poster # 67

Hearing Aids, Clinically Fit, Compared with Prescription and Self-Adjustment
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Objectives: The goal was comparison of hearing-aid real-ear outputs with those of an open-source speech-processing platform set to NAL-NL2 prescription and self-adjusted to preference by the participant.

Design: Participants were adult hearing-aid users with mild-to-moderate sensorineural hearing loss. Real-ear spectra for a speech input of 65 dB were obtained under four conditions: a) without amplification; b) with a

speech-processing platform adjusted to NAL-NL2 prescription; c) after self-adjustment of the platform to preference; d) using participants' own hearing aids, as worn. The same four conditions were used to assess phoneme recognition in monosyllabic words at levels of 45, 65, and 75 dB SPL.

Results: Group-mean real-ear measures for the three aided conditions were within a few dB of the NAL prescription for a speech input of 65 dB SPL. Similarly, phoneme recognition did not differ for the three amplified conditions when the input was at 75 dB SPL. For lower inputs, however, group-mean phoneme recognition using own hearing-aid was considerably better than that obtained with the Speech-processing platform. Analysis of individual data showed that roughly 2/3 of the participants obtained significantly better phoneme recognition scores with their own hearing aids than with the self-adjusted processing platform when listening to speech at 45 dB SPL.

Conclusions: The real-ear outputs speak well for both the NAL-NL2 prescription and for the clinical fitting protocols used in the clinics serving these participants. The superior speech-perception performance of the hearing aids for low inputs is attributed to greater amplitude compression than was used in the speech-processing platform for this study.

Poster # 68

Audibility and Acceptability of an Over the Counter Aid

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Objectives: Even with the documented risks (e.g. social withdrawal, stress, depression, dementia etc) associated with untreated hearing loss, people still tend not to buy or wear hearing aids for a variety of reasons, including cost of aids, social stigma, negative word of mouth, and inconvenience of appointments. One recently suggested solution to this problem is low-cost, over the counter (OTC) hearing aids. This study was designed to answer following questions: 1. Can one of the OTC hearing devices (IQBoost, purchased at the cost $499.00) improve the ability to understand speech in quiet and in noisy surroundings in individuals above the age of 50 years? 2. How satisfied are individuals above the age of 50 years with the OTC including the listening experience, cosmetic appearance and cost of the device? We hypothesized that the OTC may improve the word recognition scores of individuals with mild hearing loss and due to the low cost of the hearing aids, individuals may find the device acceptable.

Design: A mixed design was used. Fourteen men and 12 women above the age of 50 years volunteered for the study. All participants had a hearing loss showing thresholds of 25 dB or worse for at least one frequency in at least one ear. Word and phoneme recognition scores were obtained by presenting words at 40 dBHL through the loudspeakers in following four conditions: 1. Quiet 2. Background speech-noise 3. Quiet with the OTC (Home setting) 4. Background noise with the OTC (Restaurant setting). Participants also listened to a musical piece with and without the OTC. The participants then completed two Visual Analogue Surveys (VAS with a scale of 0 to 100 with higher numbers denoting better experience or acceptability), one with regard to their listening experience, cost and cosmetic acceptability with the OTC, and one regarding their overall everyday listening experience (without OTC). The scores on the VAS questions related to the listening experience were averaged across each participant. The average listening scores, the word % correct scores and the phoneme % correct scores were subjected to Mixed ANOVA using the following repeated factors: 1. With and without OTC and 2. quiet and noise. Gender was the non-repeated factor. Descriptive statistics were obtained on VAS questions related to the acceptability of cost and cosmetic appearance.

Results: For both OTC and no OTC conditions the word recognition scores in noise were significantly poorer than those in quiet. The OTC did not improve the word recognition in quiet or noisy backgrounds. Similarly, there were no significant differences in average listening VAS scores with and without OTC. Participants gave higher than 60 scores for questions regarding the comfort, fit and insertion of the OTC aid but the scores related to willingness to use, cost, and cosmetic appearance were less than 50. Two of the 26 participants inquired about purchasing the aids.

Conclusions: This study suggests that participants with mild to moderate hearing loss may not benefit from the OTC and the appearance of the device may have to be improved.

Poster # 69

Audiologic Services with Direct-to-Consumer Devices Improves Hearing Aid Self-Efficacy

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Objectives: Hearing aid self-efficacy has been linked to hearing-impaired individuals' decisions about device uptake, use, and success. This might not be surprising, since individuals who are confident in their ability to work through challenging issues are more likely to be open to new experiences, and to persist when they encounter difficulties. It has been suggested that audiological services can improve hearing aid self-efficacy. However, alternative service delivery models, such as those employed by manufacturers of direct-to-consumer devices, provide a different approach to orienting patients to the use and maintenance of these devices. This study aimed to explore how this increasingly popular service delivery model might impact hearing aid self-efficacy. We hypothesized that individuals would have greater gains in their hearing aid self-efficacy with traditional audiological services. In addition, we explored how cognitive ability might mediate the relative benefits of these audiological services.

Design: In a double-blinded, randomized control trial, twenty-three adults with symmetric bilateral sensorineural hearing loss participated in a one week trial with bilateral direct-to-consumer devices. No participants had prior experience wearing hearing aids. Participants were randomly divided into one of two study groups. The control group received the devices with no additional audiological intervention. The experimental group received the devices along with a comprehensive audiologic orientation covering use, care, maintenance, and recommended volume and program settings based on real-ear measures of device output. Data were collected during two appointments, before and after a one-week hearing aid trial. The Measure of Audiologic Rehabilitation Self-Efficacy for Hearing Aids (MARS-HA) was administered at both appointments to assess self-reported hearing aid self-efficacy.

Results: Preliminary analyses of these data demonstrated that, after one week of using direct-to-consumer hearing devices, hearing aid self-efficacy improved for both groups for all of the MARS-HA subscales - Basic and Advanced Handling, Adjustment to Use, and Aided Listening. However, these improvements were greater when individuals received traditional, in-person, audiological orientation and recommendations for how to use the devices (effect sizes ranged from small to moderate). Furthermore, the results of this study showed that individuals with lower cognition, defined by a measure of working memory capacity, received substantially greater gains in self-efficacy related to Basic Handling of devices when they received in-person, individualized audiologic orientation.

Conclusions: Unsurprisingly, hearing aid self-efficacy improves substantially following experience with amplification. These improvements are likely to continue as individuals gain experience with their devices over time. However, this research demonstrates that improvements can happen more rapidly when paired with in-person audiological services. It seems probable that the opportunities for early mastery experiences and psychosocial support provided by the audiologist are likely to result in greater long term hearing aid acceptance, even with direct-to-consumer hearing aids.

Poster # 70

Evaluating the Accuracy of Motion Detection Using a Behind-the-Ear Sensor

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Objectives: The present study examined the accuracy (sensitivity) of motion detection using a sensor worn behind the ears for older and younger people with normal hearing and without walking difficulties. The sensitivity of sensor performance was examined for different activities. Reliable detection was expected for regular and fast walking pace as well as standing and sitting, whereas detection sensitivity for slow walking was expected to be lower. A commercially available motion sensor worn at the hips was used as a reference for detection sensitivity.

Design: Eleven younger and 11 older adults with normal hearing, normal or corrected-to-normal vision and good cognitive and walking abilities participated in the study. Motion was detected by sensors incorporated into hearing instruments (HI) worn at the ears and a commercially available motion sensor worn at the hips. Participants were equipped with the devices and followed a guided walking track. Participants performed multiple activities with a duration of 2 minutes each (walking at different speeds, sitting, standing).

Results: The mean percentage error (MPE) is the absolute deviation in percentage between the correctly detected activity and the performed activity. Average MPE for walking was 12.1% and decreased significantly with increasing walking speed. Average MPE for detection of non-walking was 0.6%. A difference in detection sensitivity between age groups was not observed. A similar pattern in detection sensitivity was observed in the data collected by the reference device; as expected, MPE was higher for detection of slow walking with HI (25.1%) than when walking at regular and fast pace which was detected with an MPE below 10%.

Conclusions: The sensor implemented in the HI demonstrated an average MPE of less than 10% for all tested activities except one that is known for being difficult to detect. The observed error rate is regarded as acceptable for development of hearing aid features that utilize motion detection.

Poster # 71

Predicting Successful Treatment Outcomes of Hearing Aid Usage

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Objectives: Predictive models are used in health-related fields to identify patients at risk for a certain outcome (e.g. treatment outcome, incident disease). Often, predictive models are used to create clinically-useful risk scores to aid clinicians in making treatment recommendations. It is well known that few individuals who could benefit from hearing aids use them, though little is known about factors that may influence hearing aid usage. The purpose of this study is to create a predictive model that identifies factors predicting hearing aid usage in middle-aged to older adults.

Design: Individuals in this study were participants of the Beaver Dam Offspring Study, a prospective longitudinal study of aging. Individuals must have had a clinically treatable hearing loss at the baseline examination, as defined either by the World Health Organization (pure tone average (PTA), 0.5-4 kHz >25 dB HL) or the Department of Veterans Affairs (threshold ≥40 dB HL at any frequency 0.5-4.0 kHz or threshold ≥ 26 dB HL at any three frequencies 0.5-4.0 kHz), and could not be a hearing aid user at baseline. The number of individuals included in these analyses is 271. Factors collected during a typical clinical hearing evaluation were analyzed, including age, otologic and medical history, noise exposure, lifestyle factors, financial resources, self-reported hearing problems and clinical tests (audiometry, word recognition, outer/middle ear evaluation). Factors were recorded at the baseline examination (2005-08). The outcome measure of interest is use of hearing aids at the 5- or 10-year follow up examinations (2010-13, 2015-17) (n=68), measured by the question: 'Do you use your hearing aid now?' Final model selection was based on 10-fold external cross validation and least absolute shrinkage and selection operator (LASSO) regression. In LASSO regression, variables with a regression coefficient equal to zero are excluded from the model, thereby selecting coefficients most strongly associated with the outcome. The variables identified by LASSO as most strongly associated were put into a logistic regression model, which evaluated model performance with receiver operating characteristic (ROC) curves and the resulting concordance statistic (c-statistic).

Results: Of the 271 individuals in this study, the mean age was 56.6 years (range 28-84) and 22% were female. A preliminary LASSO model identified the most strongly associated predictive factors for hearing aid usage to be: worse PTA, self-report of no balance or middle ear problems, and self-reported difficulties hearing the television and in restaurants. The c-statistic for this model is 0.789 (0.72-0.85).

Conclusions: This prediction model identifies two well-known indicators of hearing aid usage (PTA, self-reported difficulties). The factors of no balance or middle ear problems will be further explored. Additionally, a second model will be created to evaluate importance of additional factors, including: clinical tests (e.g. auditory processing, otoacoustic emissions), social, demographic, medical factors and health motivation. It is possible to utilize predictive modeling methodology to enhance audiological clinical care by 1) identifying factors most

important to collect during a clinical evaluation, and 2) creating a clinically-useful risk score to predict the outcome of hearing aid usage.

Poster # 72

Do Self-Reported Sound Acceptability Measures Predict Hearing Aid Preference?

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Objectives: Loudness and/or aversiveness of amplified sound is related to hearing aid (HA) preference. Modern HA fitting practices frequently include trials with multiple HAs, often at multiple levels of technology. This research sought to determine if comparisons of reported sound acceptability in daily listening might predict final HA preferences. Also, because patient traits have been linked to overall acceptability of background noise, we explored the contributions of individual traits (personality and working memory) to these predictions.

Design: Forty-five older adults with bilateral mild-to-moderate hearing loss were recruited from the community to participate in this single-blinded, repeated, crossover trial. Participants were fitted with four pairs of HAs: basic and premium from two manufacturers (A and B) that they wore for one month each in their daily lives. Sound acceptability was assessed using retrospective self-report measures: the Aversiveness subscale of the Abbreviated Profile of Hearing aid Benefit, the Quietness subscale of the Device Oriented Subjective Outcome (DOSO) scale, and the Profile of Aided Loudness (PAL) which measures loudness ratings and loudness satisfaction ratings for soft, average, and loud sounds. Finally, we asked participants' preference between the two devices worn for each manufacturer. For analysis, we calculated the difference score (Rating with Premium Device - Rating with Basic Device) for each self-report measure. Working memory and personality were also measured. Regression and Receiver-Operating-Characteristics (ROC) analyses were performed for manufacturer A to identify significant predictors of HA preference. Working memory and personality were included as covariates. Profile analysis was performed to identify the minimum difference in scores for the DOSO Quietness subscale (the most significant contributor to the model) needed to accurately predict preference. The resulting model was applied to ratings and final preferences between devices from manufacturer B to assess the model's generalizability.

Results: Ratings on the Quietness subscale of the DOSO ($p=.013$) and two measures of the PAL: loudness rating for average sounds ($p=.031$), and loudness satisfaction rating for loud sounds ($p=.034$) were significant predictors of final HA preference for manufacturer A. Although covariate contributions were not statistically significant, their presence improved the model's ability to predict HA preference (area under the ROC curve (AUC) without covariates=.867, AUC with covariates=.901). Profile analysis revealed that, out of 10 possible difference units on the DOSO, a difference of less than one unit in either direction could accurately predict final HA preference. When we applied our model to preferences for manufacturer B's devices, the results were remarkably consistent which supported the model's generalizability.

Conclusions: Overall, these results demonstrate that even a small difference in older adults' perceived sound acceptability with different HAs can influence their final preferences. Current HA fitting practices focus on optimizing audibility and limiting maximum sound output but do not always address issues related to acceptability of sounds across the range of inputs. It is noteworthy that the Aversiveness subscale, which focuses on reactions to uncomfortably loud sounds, did not significantly predict HA preference. Future research should explore how acceptability for a variety of sound types and input levels might differently influence HA preferences.

Poster # 73

The Impact of Instant Ear Tips on Hearing Aid Fittings

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Objectives: Today, about 70-80% of hearing aid fittings are made with instant ear tips. Even though instant ear tips have become very popular, little has been published about their acoustic properties and their impact on hearing aid fittings. This study aimed to 1) investigate the acoustic properties of five instant ear tips varying from open to closed in terms of Tip Real-Ear Insertion Gain (REIG-tip), Vent Effect (VE), and the occlusion experienced by subjects. 2) Investigate the inter- and intra-subject variability across ear tips and multiple insertions.

Design: Thirty subjects with normal hearing (10 female, 19-67 years) participated in the study. Real-ear measurements were performed on both ears. Tip Real-Ear Insertion Gain (REIG-tip) was measured for each ear tip as the difference between real-ear unaided response (REUR) and real-ear occluded response (REOR). Responses were also measured using brown noise streamed to the hearing aid via a streaming device, with the ear tip inserted in the ear canal. The VE was then calculated as the difference between two measurements, the last one with the ear being additionally occluded with impression material. The intra-subject variability was tested by inserting the ear tips six times and measuring the responses after each ear tip insertion. The perceived occlusion was rated on a visual analog scale with the hearing aid turned off.

Results: The results showed statistically significant differences between the ear tips for both REIG-tip and VE. However, TIP REIG and VE also varied widely between subjects, even with the same ear tip type, indicating that all ear tips may act more or less open or closed depending on the individual's ear and the ear tip shape and size. Despite the large inter-subject variability found in the study, high intra-class correlation coefficients for repeated measures on the same individuals indicate that the acoustics of the ear tips are stable in the individual ear. The results also revealed a high correlation between VE and perceived occlusion.

Conclusions: Instant ear tips seal the ear canal less effectively than custom earmoulds, resulting both in more transparency for sounds from outside the ear canal and in a more pronounced VE. This may be desirable for sloping hearing losses, because it reduces the occlusion effect and improves comfort in the hearing aid fitting. However, the large inter-subject differences found in this study for the 5 ear tips points to the need for an individual in-situ estimate of the VE and tip REIG, since using inappropriate average values for VE compensation in the hearing aid fitting can negatively impact the sound quality and lead to either a "boomy" or a "tinny" sound.

Poster # 74

Evaluation of Hearing Aid Personalization Algorithms

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Objectives: Users of self-fitting hearing aids often need to select hearing aid configurations without assistance from professionals. While limiting the number of available configurations makes this selection process easier, it also limits the potential for personalizing the settings to a given user's needs. Conversely, offering a large number of potential configurations would allow for more personalization but would make the process of selecting one considerably more challenging. The question of how an individual might efficiently converge on an optimal configuration without examining or even knowing about all possible options was framed as a multi-armed bandit problem, where a solution requires balancing exploration of available options with exploitation of known preferences or probabilities. The purpose of this study is to evaluate the performance of five selection algorithms that could be used to simplify the process of selecting personalized settings from among a large number of possible configurations for self-fitting hearing aids.

Design: Fifteen hearing aid gain-frequency responses were developed using audiometric data from a national health database. Speech was recorded from the output of a hearing aid programmed with each of the 15 gain-frequency responses and presented to twenty older adults with hearing loss. The participants used a paired comparison paradigm to determine the order and strength of the preference of the gain-frequency responses for all possible combinations (105 pairwise comparisons x 4 repetitions). The preference data were then used to simulate the behavior of five selection algorithms for each subject: (1) single-memory algorithm, (2) eliminate-one algorithm, (3) epsilon-greedy algorithm, (4) soft-max algorithm, and (5) upper-confidence-bound (UCB) algorithm. The single-memory algorithm chooses the best configuration following each pairwise comparison and keeps it in memory until replaced after a new comparison. The eliminate-one algorithm keeps eliminating one configuration at a time after each pairwise comparison. Epsilon-greedy, soft-max, and UCB algorithms are classic multi-armed bandit algorithms. The performance of each algorithm was evaluated by how consistent (Robustness), accurate (Accuracy), and fast (Convergence Rate) an algorithm is in finding the gain-frequency response most preferred by the participant.

Results: The UCB algorithm has the best overall performance across the subjects in terms of robustness, accuracy and convergence rate when optimized for fewest number of required inputs from the user, however if a higher number of paired comparison trials is allowed, the soft-max algorithm performs better than the UCB algorithm in accuracy and robustness. The eliminate-one algorithm and the epsilon-greedy algorithm converge comparatively slower and less accurately than the UCB and soft-max algorithms.

Conclusions: The performance varies across algorithms, and there is trade-off between robustness, accuracy, and convergence rate. The data from this study can be used to develop smarter and more efficient algorithms for self-fitting hearing aids in the future.

Poster # 75

Stigma Does Not Affect Hearing Aid Purchase by New Clients

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Objectives: This study investigated how psychosocial factors were associated with first-time clients' decision to purchase hearing aids. Factors of interest were age-related stigma, hearing aid-related stigma, and social acquaintances' experiences with hearing loss and hearing aids.

Design: Participants were 2116 community-dwelling adults over 50 years of age who had never used hearing aids, and were first-time visitors to a hearing aid dispensary. Participation took place at 130 dispensaries across Canada. Participants filled out a questionnaire that included items on age-related stigma, hearing aid-related stigma, self-perceived hearing ability, and their social environment. Their pure-tone audiometric thresholds were also measured. Participants were followed for up to 15 months and their hearing aid purchase decisions were tracked.

Results: Age-related stigma did not predict hearing aid purchase, and hearing aid-related stigma was only a weak predictor of hearing aid purchase. Participants were slightly more likely to purchase hearing aids if they had at least one social acquaintance who had a suspected hearing loss, or had a hearing test done, or had had a positive experience with hearing aids. The strongest predictors of hearing aid purchase were age, pure-tone average threshold, and self-perceived hearing difficulties in socio-emotional contexts.

Conclusions: In this study, stigma-related factors either did not predict or were weak predictors of hearing aid purchase. Beyond hearing-related factors, a few factors related to a person's social environment predicted hearing aid purchase behavior by first-time clients at hearing aid dispensaries, at least in the short term (several months to a year). Healthcare professionals should be aware that, besides typical hearing-related factors, social factors may influence clients' decisions to adopt hearing aids.

Poster # 76

Intelligibility and Preference of Vocoded-Speech Under Fast- and Slow-Acting Compression

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Objectives: A consensus on proper hearing aid compression speeds (fast-acting or slow-acting) depending on listeners' hearing status has not yet been reached. Typically, an advantage of fast-acting compression is better audibility of low-level sounds, but this algorithm distorts the temporal envelope. If a hearing aid user has to greatly depend on envelope for speech understanding, a fast-acting algorithm should deteriorate performance for these listeners. In the current study, we evaluate the effects of envelope distortion on speech understanding by using noise vocoding. Since listeners rely mainly on envelope cues for the recognition of noise-vocoded speech, the temporal distortions generated by the fast-acting compression may negatively affect speech understanding compared to slow-acting compression.

Design: The current study consisted of two experiments. Twenty-one normal hearing listeners (11 in experiment 1 and 10 in experiment 2) participated in the study. For both experiments, listeners completed two tasks: intelligibility of and preference for speech processed by fast- and slow-acting compression algorithms. Stimuli were IEEE sentences added to multi-talked babble noise at various signal-to-noise ratios (5, 10, and 15 dB). In Experiment 1, sentences plus noise were noise vocoded and then three-channel compression (fast- and slow acting) was applied. For fast- and slow- acting compression, attack-times were 5 and 20 ms and release-times were 20 and 2000 ms, respectively. For both algorithms, the compression threshold was 40 dB SPL and the compression ratio was 2:1. Before compression, the input level was adjusted to 65 dB SPL, simulating a slow-acting broadband automatic gain control, while the output level from the compressor was adjusted to 65 dB SPL. Besides measuring speech recognition performance, listeners' preference on compression speed were also measured via paired-comparison. Experiment 2 was the same as experiment 1 except the stimuli were not noise vocoded and lower signal-to-noise ratios were tested (-5, 0, and 5 dB).

Results: For both Experiments 1 and 2, significant effects of compression speed on intelligibility were observed, with fast-acting compression having lower performance than slow-acting compression. Listeners preferred sentences processed with slow-acting compression to those processed with fast-acting compression for all signal-to-noise ratios in both experiments.

Conclusions: Listeners' speech-recognition performance were better with slow- than fast-acting compression, and listeners also showed preferences for slow-acting compression, regardless of whether the stimulus was noise-vocoded. Thus, for the conditions evaluated in the current study, the effect of compression speed is not sensitive to the presence of TFS cues.

Poster # 77

Behavioral and Physiological Amplification Effects in New Hearing Aid Users

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Objectives: Success with amplification varies among individuals, especially in difficult listening situations with background noise. For the new hearing-aid user, immediate improvements in physiological coding and behavioral speech understanding would be expected as a result of increased access to auditory inputs. However, results in the literature are variable with regard to enhancements in cortical auditory evoked potentials (CAEPs) after amplification. For example, in some cases where supra-threshold stimuli were used, no difference was found between unaided and aided CAEPs. Therefore, we have hypothesized that aided CAEPs are most sensitive to the effects of amplification (i.e., enhanced CAEPs in the aided condition compared to the unaided condition) when unaided stimuli are presented at/below threshold rather than at suprathreshold levels (Billings, Papesh, Penman, Baltzell, and Gallun, 2012). In addition to unaided audibility, other factors that may influence the magnitude of amplification effects include signal-to-noise ratio, listener hearing status, and hearing-aid signal processing. The objective of the current study was to determine the effects of amplification and explore the contributions of audibility using unaided/aided CAEPs and speech-understanding-in-noise measures in new hearing-aid users.

Design: Seventeen individuals with bilateral sensorineural hearing loss were fit with bilateral receiver-in-the-canal hearing aids. None of the participants had prior hearing-aid experience. CAEPs (N1-P2 complex) were recorded and the Words in Noise (WIN) test was administered at baseline, pre-fit, and post-fit time-points. CAEPs were elicited to the naturally spoken syllable /sa/ presented in the soundfield at 65 and 80 dB SPL in aided and unaided conditions. The intensity contrast present between the lower-level /s/ relative to a higher-level /a/ will allow exploration of effects of audibility on CAEPs. The WIN was also administered in unaided and aided conditions. Hearing-aid output measurements were obtained for each participant’s hearing aids using a head-and-torso simulator. Output measurements will be compared to each participant’s audiometric thresholds to determine audibility of stimuli.

Results: Preliminary results show a group amplification effect for CAEP and WIN data such that, on average, CAEPs become more robust (e.g., increased N1 peak amplitude) and WIN scores improve in the aided condition compared to the unaided condition. For CAEPs, amplification effects were more robust for near-threshold portions of the stimulus (i.e., /s/) than for supra-threshold portions of the stimulus (i.e., /a/). Audibility

of the /s/ and /a/ will be determined for individuals and compared with CAEPs to ascertain the degree of agreement between audibility and brain measures.

Conclusions: Results from behavioral and physiological measures alike reflect improved audibility as a result of amplification. However, taken together with the existing literature, these results suggest that CAEPs reflect amplification effects for a near-threshold stimulus more readily than for a supra-threshold stimulus. Therefore, the clinical utility of aided CAEPs for supra-threshold application may be more limited than for near-threshold uses. [Work supported by VA/RR&D, award #C2396P]

SPEECH PERCEPTION

Poster # 78

Mandarin Tone Perception in Multiple-Talker Babbles and Speech-Shaped Noise
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Objectives: Speech perception of English consonant sand sentences in multiple-talker babbles showed a nonmonotonic function with the number of talkers in the speech babbles. The performance typically reached a lowest point at the number of talkers of 2 to 8 depending on the speech materials. The present study aims to investigate the perception of lexical tones in multiple-talker babbles consisting of different numbers of talkers (N) and in speech-shaped noise at different signal-to-noise ratios (SNR) in normal-hearing, native-Mandarin speaking adults. We hypothesized that the tone perception performance as a function of the number of talkers in multiple-talker babbles would be similar to that of English speech perception in multiple-talker babbles. We also attempted to identify the number of talkers in the speech babbles that produced the maximum masking for lexical tone perception.

Design: Thirty normal-hearing, native Mandarin-speaking adults (15 males and 15 females) aged between 18 and 30 years old were recruited. All participants were screened for normal hearing (≤ 20 dB HL) at octave frequencies between 250 and 8000 Hz. No participants had any history of speech or hearing disorders. We used ten duration-equalized Chinese monosyllables with four tones for each, spoken by one male and one female as target material. Multiple-talker babbles with different N (i.e., 1, 2, 4, 8, 10, and 12 talkers) and speech-shaped noise were used as maskers. Targets and maskers were mixed at different signal-to-noise ratios (SNR) (i.e., -6, -9, -12, and -18 dB). The tone perception performance was measured at each combination of noise type and SNR based on a four-alternative-forced choice (4AFC) procedure through a custom MATLAB program.

Results: Results showed that tone perception performance was nearly at ceiling for -6 dB SNR and ranged from 80% correct to chance performance (i.e., 25% correct) from -9 dB to -18 dB SNR. The tone perception performance as a function of N was non-monotonic decreasing and the breakpoint at which the performance plateaued was at 8 talkers at all SNRs tested. The breakpoint in the present study was comparable to that in English consonant perception in multiple-talker babbles at -6 dB SNR as reported in the literature. The improvement of performance when N was greater than the breakpoint (N = 8) was observed only at -6 and -9 dB SNRs but not -12 and -18 dB SNRs.

Conclusions: Lexical tone perception was robust to the masking effects of speech babbles and speech-shaped noise. The breakpoint in perception performance of lexical tones in multiple-talker babbles as a function of N

was comparable to that of English consonant perception performance but at a much lower SNR. The improvement in tone perception performance after breakpoint only presented when SNR was better due to the mixed effect of informational masking release and energetic masking.

Poster # 79

Korean Speech Intelligibility Index for Listeners with Hearing Loss
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Objectives: The purpose of the current study is to derive band-importance function and transfer function for Korean listeners with moderate-to-severe sloping hearing loss. Compared to the Speech Intelligibility Index for Korean listeners with normal hearing, we propose a different band-importance function and transfer function based on the altered auditory sensitivity.

Design: Seventy-eight native Korean adults with moderate-to-severe sloping hearing loss participated in the present study. Intelligibility was measured using 5 signal-to-noise ratios and 42 filtering conditions. The presentation level for speech intelligibility measurement was 30 dB Sensation level. Band-importance function and transfer function were calculated using a nonlinear optimization function by MATLAB.

Results: The Speech Intelligibility Index for Korean listeners with moderate-to-severe sloping hearing loss required a different band-importance function and transfer function compared to that of Korean listeners with normal hearing. Unlike the band-importance function for listeners with normal hearing, high-frequency areas were found to be more significant for listeners with moderate-to-severe sloping hearing loss. Also, a more gradual variation of the transfer function was observed compared to the transfer function for listeners with normal hearing.

Conclusions: Predicted speech intelligibility may vary depending on the auditory sensitivity of listeners at the same audibility levels. Therefore, development of the Speech Intelligibility Index appropriate for the auditory sensitivities of listeners may be required for more accurate prediction of speech intelligibility.

Poster # 80

The Effect of Talker Familiarity on Children's Speech-in-Speech Recognition
Mary Flaherty, PhD, University of Illinois at Urbana-Champaign, Champaign, IL

Objectives: The goal of this study was to evaluate the extent to which talker voice familiarity impacts school-age children's ability to recognize speech in a competing speech masker. It is well established that children have more difficulty than adults when understanding speech in multitalker environments. Recent research has focused on the acoustic voice cues that can improve children's speech-in-speech recognition, but little attention has been given to the ways children's prior experience, or familiarity, with a talker's voice might impact these processes. Talker familiarity has been shown to aid in spoken word recognition in quiet for children with normal hearing and can improve word recognition in the presence of a competing talker for infants and adults. The current study examines the ways that talker familiarity influences children's speech-in-speech recognition, using the child's mother's voice as either the target or masker speech. It was hypothesized talker familiarity

would aid target/masker segregation due to increased listening experience with talker-specific voice characteristics, thus improving speech-in-speech understanding for children.

Design: Listeners were children (ages 5-17 years) with normal hearing. Open-set sentence recognition was measured adaptively in a two-talker female speech masker. All stimuli were produced by the female adult mothers of each participating child. All talkers had a standard American English dialect. During testing, children heard three voices: their mother's voice and two unfamiliar voices. There were three conditions: (1) Familiar Target + Unfamiliar Masker, (2) Unfamiliar Target + Familiar Masker, and (3) Unfamiliar Target + Unfamiliar Masker. Condition 1 allowed us to measure the effect of a familiar target talker, while Condition 2 allowed us to examine the effect of a familiar background talker. Condition 3 served as a baseline condition. Results were examined for effects of age and target/masker talker familiarity.

Results: Our preliminary results found that sentence recognition thresholds generally improved when the target talker was familiar compared to when the target talker was unfamiliar, with the younger children (ages 5-11 yrs) showing a greater benefit than the older children. When the masker was the familiar talker, all children performed more poorly compared to when the masker was an unfamiliar talker. This familiar-masker effect tended to be larger for younger children than for older children.

Conclusions: These initial findings suggest that talker familiarity improves children's speech-in-speech recognition when the target is a highly familiar talker, but not when the masker is highly familiar. The magnitude of these effects appears to be influenced by listener age. There are a variety of ways that familiarity with a voice may impact performance. Knowing the vocal characteristics of the target talker may facilitate stream segregation and enhance children's ability to attend to target speech and ignore background speech. Children's poorer speech recognition with a familiar masker suggests that children have difficulty ignoring a familiar voice, even when it is not the focus of attention. This differs from recent findings in adults, who show a speech recognition benefit when the masker (or target) is highly familiar. Reasons for and implications of these child/adult differences will be discussed.

Poster # 81

Immediate and Ongoing Cost of Repairing Errors in Speech Perception
Matthew Winn, AuD, PhD; Katherine Teece, AuD, University of Minnesota, Minneapolis, MN

Objectives: By using linguistic knowledge and context, listeners can transform incorrect perceptions into "correct" responses in speech intelligibility tests. Although this is a useful skill in everyday life, it means that intelligibility scores cannot distinguish a listener who correctly repaired misperceptions from a listener who simply heard the speech clearly and accurately with no need for repair. Repairing errors is likely a major part of what makes listening effortful for people with hearing loss, and therefore there is a need to design tests that specifically capture this phenomenon. This study presents a new test that is designed specifically to evoke error-correction behavior, and to quantify the cost of repairing errors, in terms of listening effort and processing time.

Design: The task was designed to explicitly demand error correction, using a novel set of sentences where early-occurring target words are either spoken normally, replaced by noise, or intentionally mispronounced in a way that would match common perceptual errors made by individuals with hearing loss. These misperceived words can be recovered by later context designed to constrain the range of possible words that would fill in that gap. Cognitive repair of speech was verified when listeners heard a masked/mispronounced word but restored to its likely target to report a full well-formed sentence. For example, for "The woman xxxxx her candle with a

match", a listener who correctly inserts the word "lit" has demonstrated cognitive repair. During the task, listening effort was measured using pupillometry, which can capture changes in cognitive load moment-by-moment as the sentence is heard, processed and repeated. Participants include 12 listeners with cochlear implants and 20 listeners with normal hearing.

Results: For listeners with and without cochlear implants, pupillometry results revealed the cost of repairing missing words. When individual words were masked by noise, there was a considerably steeper growth of pupil dilation which sustained over a longer period of time, compared to sentences with no masked words. Listeners with cochlear implants were not as responsive to words that are mispronounced, possibly indicating that the "intact" speech was already being misperceived and corrected quite often, in a way that was not detected by intelligibility scores. Pupil micro-dilations were aligned with the onset of a missing piece of the signal. Listeners with cochlear implants showed less recovery from peak effort compared to those with normal hearing, suggesting ongoing effort and uncertainty about what was heard, even if the responses were correct. Sentence intelligibility scores were near perfect for most listeners for all types of sentences.

Conclusions: Intelligibility scores do not differentiate between situations where a sentence is heard correctly versus situations where a sentence is repeated correctly after mental effort to repair misperceptions. People with cochlear implants likely perform mental corrections more often than what would be expected from their scores, and also seem to continue demonstrating effort / uncertainty well after an utterance has been heard. This lingering "extra moment" of effort could jeopardize tracking of ongoing conversation - a difficulty that would not be directly captured by standard intelligibility scores.

Poster # 82

Building a Test Battery to Validate Speech in Noise Complaints

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Objectives: Difficulty hearing speech in noise (SIN) is a chief complaint of individuals with hearing loss. However, individuals with clinically defined 'normal' hearing also struggle with understanding speech in complex listening environments; affecting some to the point of seeking help from an audiologist. There are currently minimal resources audiologists can use to validate a normal-hearing patient's reported SIN difficulties. More attention must be paid to this sub-clinical population, as such problems can lead to similar detrimental effects on their well-being that are seen in cases of untreated hearing loss (e.g. progressive social isolation). The current objective of this study was to optimize a test battery using clinically available tools to predict and validate an individual's SIN performance.

Design: 58 older adults (mean age = 52.8) with normal hearing (4-frequency PTA $\leq$ 25dB) completed a test battery of clinical measures. Measures included (1) pure-tone audiometry (0.25-8k), (2) SIN performance using the modified QuickSIN, (3) a questionnaire quantifying perceptual SIN ability, (4) click-evoked auditory brainstem responses (ABR) and (5) in a subset of participants (n = 24), a screener for central auditory processing disorders (CAPD): SCAN-A.

Results: A total of 12 variables were initially analyzed from the first four clinical measures. By utilizing a stepwise multiple linear regression (MLR) analysis, a model was developed that best predicted SIN performance. The results of the MLR analysis indicated that the model explained 33.8% of the variance in SIN performance. The variables that significantly contributed to the model were 4-frequency PTA and 8000 Hz

threshold. The fifth clinical measure, SCAN-A, was not included in the MLR analysis due to administering it only to a subset of participants. Simple linear regression analysis showed a significant correlation between SIN performance and total score of SCAN-A, even when controlling for age - a covariate for both measures.

Conclusions: The results of our MLR analysis suggest that the complaint of SIN difficulty despite 'normal' hearing may be attributed - in part - to dysfunction in the auditory periphery. Contributions from 4-frequency PTA and 8000 Hz threshold demonstrate the roles that audibility and high-frequency hearing play in discriminating speech from noise. Notably, our model showed that the wave I amplitude of the ABR was not a significant predictor of an individual's SIN performance. This suggests that deficits at the level of the periphery may not be detectible in humans using the ABR. Rather, the relationship between SIN performance and SCAN-A score suggests an additional central involvement. Ultimately, we conclude the clinical utilization of pure-tone audiometry and a CAPD screener could aid in predicting and validating an individual's SIN complaints. Moving forward, a few modifications should be made to improve the test battery's predictive performance: (1) pure-tone audiometry should include extended high frequencies, (2) a more sensitive objective measure of peripheral function should be used, such as electrocochleography (ECochG), and (3) the relationship between SIN performance and different subtests of the SCAN-A - representing distinctive central auditory processing involvement - should be analyzed, so that more specific CAPD clinical measures could replace the SCAN-A screener.

Poster # 83

Fundamental Frequency Range and the Clear-Speech Benefit

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Objectives: An increase in the range of a talker's fundamental frequency (F0) is known as one of the several acoustic changes that are observed when clear speech is produced. Although an expanded F0 range is often seen in the production of clear speech, its contribution to the intelligibility benefit of clear speech is unknown. The primary focus of the present study is to assess the role of F0 variation on the intelligibility benefit of clear speech in native speakers of American English.

Design: Conversational and clear speech were recorded by four adult male native speakers of Midwestern American English with no history of a speech-language-hearing disorder. During the recording session, participants were instructed to read aloud low-context sentences in conversational and clear speaking styles. To characterize clear-speech adjustments, five acoustic-phonetic properties were measured: F0 range, speech rates, long-term spectra, vowel space, and vocal intensity levels. To examine whether the change in F0 variation contributes to the intelligibility benefit of clear speech, F0-manipulated speech was synthesized from the clear speech by compressing the F0 contours of clear speech to match those of conversational speech. Fifteen adult native listeners of American English with normal hearing were randomly presented with sentences in three different speaking styles (i.e., conversational, clear, and F0-manipulated speaking styles) under speech-shaped noise and asked to type in the sentence after orally repeating each sentence that they heard. The percentage of correct keywords was calculated for each speaking style.

Results: In a clear speaking style, talkers typically increased F0 variation, high-frequency energy, F1/F2 vowel space size, and vocal intensity levels, while decreasing speaking rates. All talkers showed substantial intelligibility benefits from clear and F0-manipulated speech when compared with conversational speech. The F0-manipulated speech did not significantly differ from the clear speech in performance across talkers.

Conclusions: The present study provides experimental evidence that the change in the F0 range of clear speech is not a primary factor that directly contributes to the clear-speech benefit. Rather, it may be a secondary effect that is accompanied by other acoustic changes that convey clear speech benefits, such as a slower speaking rate or segmental hyperarticulation. These findings have implications for optimizing communication between healthcare providers and patients with hearing problems.

Poster # 84

Hey Siri? You Make Listening Easy

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Objectives: Previous work has shown that familiar voices are easier to understand in the presence of an unfamiliar competing masker. In this work we extend these findings to a virtual assistant, Siri, that is available on Apple devices.

Design: Thirty adult listeners (6 males, 24 females) with normal hearing were recruited. Participants performed a complex hearing task called a coordinate response measure (CRM). Participants listened through speakers to a target (identified as Baron) saying a coloured number (one out of 32 options; 4 rows of differently-coloured numbers from 1 to 8) while simultaneously listening to a masker saying another call sign. Participants were asked to identify the target coloured number via a mouse. In one of the blocks, participants listened to a familiar target voice (i.e., Siri) and an unfamiliar masker voice (i.e., alternate Apple voice "Allison"). In the other block, participants listened to two unfamiliar voices (one target "Samantha" and one masker "Allison"). When the participant chose the correct Baron call sign, the level of the next target dropped by 1dB. When participant chose the incorrect call sign, the level of the next target increased by 3dB. This held the participant performance at a 75% accuracy. After 40 reversals, the target to masker ratio was calculated for each block. Additionally, there were two other outcomes of interest. First, there was an "unexpected" working memory block at the end of the CRM, where participants were asked to recall the last 5 Baron call signs. There were then two more "expected" working memory blocks where participants were asked to recall as many Barons as possible. Finally, we tracked pupil diameter for all trials in the experiment.

Results: Our participants were familiar with Siri's voice and were able to hear Siri's voice at a target to masker level 2.53 dB better than the alternate Apple voice "Samantha". As expected, recall in the unexpected working memory block was poor as subjects were primarily using a strategy of listening only. Performance improved for both voices in the "expected" working memory condition but target to masker ratio suffered as participants began to employ a strategy of listening to and retaining information. Finally, we found that, not only was Samantha harder to hear than Siri, when listening to Samantha, participants peak pupil dilation was greater, indicating that more effort was used to listen to this unfamiliar Apple voice.

Conclusions: Several possible explanations for these differences are discussed, including implications for people with hearing loss as well as normal hearing.

Poster # 85

Complex Modulation Spectrum and Consonant Intelligibility

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Objectives: Envelope modulations are crucial for understanding speech, and factors that can distort these modulations (e.g., reverberation, noise) degrades speech perception. Metrics based on the modulation spectrum have been proposed to measure and predict speech intelligibility. The peak amplitude of the complex modulation spectrum is one such metric that has been shown to predict intelligibility of locally time-reversed English sentences. However, it is not clear whether this peak, which corresponds mostly to the average syllable rate of speech can predict the intelligibility of consonants, which are much shorter than phrases, words, and syllables. The current study tested this hypothesis for consonant recognition in three different types of distortions - noise masking, local time reversing, and syllable rate.

Design: For each of the three types of distortions, normalized complex modulation spectra (CMS) were estimated for the corresponding speech stimuli. The peak amplitude of these normalized CMS was compared with the average consonant recognition score in each condition (i.e., at each SNR in noise masking, at each reversal duration in local time reversing and at each syllable rate in the syllable rate variation study). Normalized CMS were also estimated for individual consonants and, their peaks amplitudes were compared with individual consonant scores.

Results: The peak of the complex modulation spectrum was found to highly correlate with the average consonant recognition in all three types of distortions. However, the peak could not predict the intelligibility of individual consonants.

Conclusions: Peak amplitude of the complex modulation spectrum can be used to predict the degrading effect of various types of distortions on average speech intelligibility, for both sentences and consonants. However, it cannot predict intelligibility of individual consonants, suggesting that the complex modulation spectrum may not be characterizing perceptual features that contribute to intelligibility. Rather, it seems to be an indirect measure that characterizes the overall degradation of speech signal, which would also degrade perceptual features.

Poster # 86

Speech-in-Speech Recognition and Spatially Selective Attention in Children and Adults

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Objectives: Knowing target location can improve adults' speech-in-speech recognition in complex auditory environments. We do not know if young children can preferentially attend to cues from a particular spatial location or how this ability develops as they approach adulthood. This two-part study evaluated masked word recognition for targets with and without a pre-trial cue to location in children and young adults. The goal was to characterize the influence of age and masker type on participants' use of spatial cues.

Design: Participants were children (5-13 years) and young adults (18-35 years) with normal hearing. Testing took place in a 180° sound-arc of eleven evenly spaced loudspeakers. Targets were spondee words produced by a female talker and presented from a randomly-selected speaker. Maskers were sequences of brief stimuli comprising either speech-shaped noise bursts or spondees. Each masker burst or word was presented from a randomly-selected speaker, and each masker spondee was spoken by a randomly selected voice from a set of three talkers (2M & 1F). Prior to each trial, participants heard the sentence, “The sky was very blue,” spoken by the target talker. In the location-known condition, this pre-trial cue indicated the location of the subsequent

target. In the location-unknown condition, the location of the sentence was random. Experiment 1 measured performance with two interleaved adaptive tracks, and trial-by-trial data were fitted with a psychometric function to estimate the speech reception threshold (SRT). Maskers were speech-shaped noise bursts, one-talker speech, and three-talker speech. Experiment 2 measured an SRT with three-talker speech masking and used that target-to-masker ratio for fixed-level testing; errors in fixed-level data were analyzed to estimate spatial selectivity of the participant's listening strategy.

Results: The primary measure for Experiment 1 was benefit associated with pre-trial location cue. Both children and adults benefitted from the pre-trial cue with the three-talker masker in the location-known condition. Whereas adults performed equally well in the location-known and location-unknown conditions with the one-talker masker, preliminary data indicate that children benefit from prior information about target location for this masker. Neither group benefitted from prior information about the target location in the noise masker. The primary measure for Experiment 2 was error analysis, evaluating the location of intrusions (masker words mistaken for the target). In the location-known condition, intrusions tended correspond to speakers near the cued speaker. However, there were large individual differences; for some adults and children, intrusions deviated markedly from the cued location. In the location-unknown condition, data suggest a broad listening strategy across the speaker array for most participants.

Conclusions: Results of this study suggest that children and adults benefit from pre-trial cues that indicate target location in speech-in-speech listening tasks, but the magnitude of this benefit is smaller for children than adults. In contrast to speech maskers, neither group benefitted from a pre-trial cue for the noise masker. This effect of masker type reflects the importance of spatially selective attention under conditions of informational masking. As data collection continues, we expect to evaluate effects of maturation on selective attention to location for these tasks.

Poster # 87

Measuring Listening Difficulties in Children with Speech in Noise Tests

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Objectives: About 5-10% of children referred to audiology services have listening difficulties (LiD), but normal hearing, as measured by standard clinical tests. Speech in noise tasks are one way to measure the impact of listening difficulties in an applied communicative setting. One such task is Listening in Spatialized Noise – Sentences (LiSN-S), which assesses the ability to understand target sentences presented in multi-talker babble. Repetition-response protocol is used to determine a participant’s speech reception threshold (SRT) in four different conditions (2 talker conditions and 2 spatial conditions). Another speech in noise task used only during Wave 2 is Digits in Noise (DiN), in which participants listen to digit triplets presented either collocated (00) with babble noise or separated (±90 o) from babble noise. DiN is similar to LiSN-S but simpler because it does not have such intensive cognitive demands to repeat back digits.

Design: A sample of 39 LiD participants and 42 typically developing (TD) participants completed the LISN-S at two time points 2-3 years apart (time points will be referred to as Wave 1 and Wave 2). Scores are scaled as z-scores, adjusted for age. In the first condition, High Cue SRT, the target and background speakers have different voices and the target is at 0 degree azimuth, while the background talkers are at ±90 azimuth. This allows the participant to spatially separate the background from the target. In the Low Cue SRT condition, the background talker has the same voice as the target speaker and it comes from the same direction (00) as the

target speaker. Spatial advantage measures the difference between moving the distracting speakers from ±90 o to 00 with the same voice as the target speaker.

Results: For High Cue SRT, TD participants performed significantly better than LiDs($F(1,79)=10.15$, $p<0.002$) in both waves. No significant difference was observed in this task between Wave 1 and Wave 2. For Low Cue SRT, there was a significant difference between TDs an LiDs ($F(1,79)=25.81$, $p<0.001$) in both waves, but their scores did not significantly changed between Wave 1 and Wave 2.. The use of spatial cues to determine target speakers is measured in the spatial advantage score, which did not show a significant group difference, or difference between Wave 1 and 2. Talker advantage examines the ability to differentiate between different speaker voices, which showed a significant difference between TDs and LiDs ($F(1,79)=9.018$, $p<0.0004$) but no significant difference in Wave 1 vs Wave 2. In DiN, LiD children (n=17) performed significantly more poorly than TD children (n=18) at 90o ($F[1,33]=7.8$, $p=0.008$), resulting in less spatial release from masking (SRM) ($F[1,33]=5.3$, $p=0.03$). There was also a significant correlation between DiN-SRM with LiSN-S spatial advantage ($r=0.43$, $p=0.008$).

Conclusions: We found that LiD participants had a diminished ability to differentiate target signal from background noise in most tasks. A related difference in SRM and Spatial Advantage between groups shows evidence that activity in the central auditory nervous system (CANS) could contribute to listening difficulties in children.

Poster # 88

Musical Training Effects on Speech in Noise in Older Adults

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Objectives: As we age, we tend to have more difficulty understanding speech in the presence of background noise, an important part of everyday life. This difficulty is often greater than what hearing thresholds would suggest. The factors leading to poorer speech understanding with age are still unknown, but are likely a combination of changes in the cognitive and auditory systems. Music training has been proposed as a possible target for auditory training, as it may improve both auditory and cognitive skills. However, the evidence to support such benefits from music training is mixed. The goal of this study was to determine the differential effects of lifelong musical training and working memory on speech in noise understanding in older adults. We hypothesized that musicians would perform better on speech in noise tests. Additionally, we predicted that regardless of musical training, participants with higher working memory capacity would perform better on speech in noise tasks than those with lower working memory scores.

Design: A total of 30 individuals aged 65-85 years old participated in this study. Participants were divided into two groups: musicians (n = 15) and non-musicians (n = 15). Musicians started their musical training by age 9, had at least 5 years of musical training, and were currently practicing. Non-musicians had no more than 3 years of musical experience throughout their life. All participants had a normal pure-tone average on audiometric testing and no significant history of additional noise exposure (excluding during musical practice). Working memory was assessed with the backward Digit Span and Reading Span tests. Speech in noise understanding was measured using the Quick Speech-in-Noise Test (QuickSIN), Hearing in Noise Test (HINT), and the Speech Perception in Noise test (SPIN).

Results: Preliminary data analysis shows that there are no significant differences between musicians and non-musicians on the outcome measures examined in this study. Additionally, preliminary results do not support an association between working memory capacity and speech in noise performance. Hearing thresholds were not significantly different between the two groups.

Conclusions: Results from this study suggest that lifelong music training may not lead to improved speech recognition in noise. It is possible that prolonged exposure to high sound levels during music training may counteract potential benefits of music training. Implications for future studies will be discussed.

Poster # 89

Spectral and Temporal Cues for Speech Understanding in Bimodal Listeners

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Objectives: The first objective of this study was to investigate the use of spectral and temporal cues to word-initial voicing (F0 and voice onset time [VOT]) in bimodal listeners, who either used their CI alone or their CI and hearing aid (CI+HA), and listeners with normal hearing (NH). We hypothesized that in the CI-alone condition, bimodal listeners will exclusively use the temporal cue (VOT) due to poor transmission of the spectral cue through the CI. Further, we hypothesized that in CI+HA listening, bimodal listeners would use both cues analogous to NH listeners. The second objective was to investigate the use of dynamic pitch for word recognition in bimodal (CI-alone and CI+HA) and listeners with NH. We hypothesized that in CI+HA listening, greater dynamic pitch would lead to better word recognition outcomes. However, changes in the degree of dynamic pitch would not benefit CI-alone listening or NH listeners.

Design: Ten listeners with NH (mean age 27.5 years) and 10 adult bimodal listeners (mean age 59.7 years) participated in the study. Bimodal listeners had >6 months CI experience and HAs were verified to NAL-NL2 targets. For the consonant voicing perception task, we created synthesized stimuli interpolated between /ba/ and /pa/ exemplars at 5 different VOTs and 5 different F0 shifts (rising to falling F0). Stimuli were presented at 65 dB SPL in the sound field. For the word recognition task, the F0 of consonant-nucleus-consonant (CNC) word lists were modified to create 4 different degrees of pitch dynamics: halved (monotone), normal (unprocessed), doubled, and tripled. The words were presented at 65 dB SPL in the presence of a continuous multi-talker babble at a +10 dB SNR for bimodal listeners and 0 dB SNR for NH listeners. The bimodal listeners also completed a battery of tests including standard audiometric and speech recognition assessment.

Results: In the voicing perception task, both VOT and F0 influenced NH and CI+HA bimodal listeners' perception of voicing. VOT, but not F0, influenced CI-alone bimodal listeners' perception of voicing. In the word recognition task, CI+HA bimodal listeners exhibited lower accuracy with greater pitch dynamics (as assessed by testing for a linear effect). Differences in pitch dynamics did not affect CI-alone and NH recognition outcomes. Follow-up comparisons found lower accuracy on processed compared to unprocessed stimuli for the CI+HA and NH listeners. There was considerable variability in performance across bimodal listeners. For that reason, we ran correlations between degree of bimodal benefit derived in word recognition in noise task with unprocessed F0 as compared to manipulated F0. We did not find any relationship between degree of bimodal benefit and audiometric thresholds.

Conclusions: Bimodal listeners make use of spectral information available in their aided hearing during speech comprehension. This information is used in similar ways to NH listeners in our voicing perception task. However, the manipulation of this information did not improve outcomes in our word recognition task.[Supported by NIH-NIDCD T35DC08763]

Poster # 90

Vocoded Speech In Noise Recognition and Working Memory

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Objectives: Listeners with cochlear implants often struggle to understand speech in noise. This struggle could be associated with several different components of the problem, including individual differences in working memory, stream segregation, and poor-quality representation of the target speech. The goal of this project was to determine how different target-masker combinations affect the relationship between aspects of working memory (storage and processing) and speech recognition. In young adults with typical hearing, vocoded speech recognition is associated with the ability to store sequences of information. The cognitive skills required to support speech recognition change across different adverse listening conditions, so we expected to observe similar changes here. Specifically, we expected storage to be more strongly associated with speech recognition in easier listening conditions, but processing to be more strongly associated with speech recognition in difficult conditions. When target speech is segregable from the masker or the masker does not contain speech information, speech cues from the target stream can be readily mapped to their corresponding linguistic representations, and so less demand is placed on processing. Conversely, multi-talker streams that are not segregated are harder to extract relevant speech cues from, so more processing is required.

Design: We tested PRESTO sentence recognition across different masking conditions and signal to noise ratios. Participants were assigned to one of two listening conditions. In the easier condition, the masker was speech shaped noise and was vocoded using a different carrier than the target speech (pure tones and bandlimited noise). In the more difficult condition, the masker was two concurrent talkers taken from unused PRESTO sentence sets and both the target and masker were vocoded using a sine-wave carrier. In both listening conditions, signal-to-noise ratios were varied from +10 dB to 0 dB in 2 dB increments. Working memory tests were designed to characterize individual differences in both storage and processing aspects. Spoken digit span primarily assessed storage, reading span primarily assessed processing, and free recall of visually presented words was scored to provide estimates of both storage and processing. Correlations between these aspects of working memory and speech recognition at different signal-to-noise ratios were compared across groups.

Results: As expected, target-masker segregation and energetic vs information masking altered speech recognition accuracy. However, in contrast to vocoded speech in quiet, preliminary results suggest that there is not a clear correlation between either storage or processing and vocoded speech in noise recognition accuracy across either listening condition.

Conclusions: Listening to degraded speech in noise seems to shift which aspects of working memory support speech recognition. Attentional mechanisms may also need to be included to explain the lack of clear relationship between vocoded speech in noise and working memory.

Poster # 91

Hearing Loss and Amplification in Clinical and Complex Speech Perception

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Objectives: Current clinical speech perception measures might not accurately depict a patient's functioning and the benefits of rehabilitative devices in complex acoustic environments. This research evaluated the effects of hearing loss and device benefit on speech perception in both clinical-based and complex acoustic environments. We hypothesized that individuals with hearing loss will perform worse than normal hearing individuals, and that measured device benefit will differ between clinically-based and more acoustically complex speech perception measures.

Design: Adults with normal hearing and adults with bilateral hearing aids participated in this study. All participants completed speech perception tests in the sound field, which included a clinically-based version and versions in complex acoustic environments. Hearing aid participants with a pure-tone average (PTA) of less than 50 dB HL completed testing with bilateral hearing aids and without hearing aids. Participants with a PTA greater than 50 dB HL were tested with just one hearing aid and with both hearing aids. An 8-speaker array with speakers surrounding the participant at 0, 45, 90, 135, 180, 225, 270, and 315 degrees was used in this study. All speech was presented at 60 dBA and the noise was adjusted to obtain the desired signal-to-noise ratios (SNRs).AzBio sentence recognition was tested as recommended in the Minimum Speech Test Battery for adults with cochlear implants with co-located speech and babble in quiet and at SNRs of +5 and +10 dB for adults with hearing loss and 0, +5, and +10 dB for adults with normal hearing. AzBio sentence recognition was also tested in R-space restaurant noise presented from eight speakers surrounding the participant. Testing was completed at a series of SNRs without hearing aids, or with just one hearing aid, to estimate an SNR for 75%-word recognition. Participants were then tested at that SNR (SNR75), in both hearing aid conditions for adults with hearing loss. The QuickSIN test was completed in three conditions: a clinically-based method, a spatially-separated target (0 degrees) and symmetrically placed background babble (+90 and -90 degrees), and spatially-separated target and babble with an added reverberant room simulation (reverberation time of 150 ms).After each test, participants were asked to complete a Likert-point survey regarding their enjoyment of the task, the similarity to their daily listening experiences, and how much they perceived their hearing aid(s) benefited them on the task, if applicable.

Results: Preliminary results demonstrated that adults with normal hearing outperformed adults with hearing loss on all speech perception tests, with a greater effect on the acoustically-complex speech perception measures. More complex acoustic environments revealed varying effects of hearing-aid benefit across participants, increasing or decreasing measured device benefit as compared to the clinical tests. These results were somewhat corroborated with survey results for difficulty and hearing aid benefit.

Conclusions: The variability of device benefit and hearing loss effects in this study suggests that routine clinical testing may not appropriately evaluate everyday hearing function. Individuals with mild to moderate hearing losses in particular need to be evaluated in more acoustically-complex environments to appropriately demonstrate the benefits and detriments of hearing-aid use.

Poster # 92

Effect of Aging on the Segregation of Familiar Voices

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Objectives: Communicating in a real-world environment requires the listener to attend to target speech that is embedded in a mixture of competing speech and noise. Speech understanding in real-world environments can be very challenging even for the ideal listener - a young adult with normal hearing. Older adults may have great difficulty segregating the target speech message from the competing background environment. One cue that has been shown to improve older adults' speech understanding in noise is their familiarity with the target talker (e.g., spouse). A potential mechanism for this benefit is that the familiar voice (FV) captures the listener's attention and improves their ability to segregate the target FV from the background. However, this reasoning would suggest that if the salient FV was in the background (masker), it would cause a shift in attention from the target talker. The objective of this experiment is to measure the effect of a FV on speech understanding in a cocktail-party scene. We hypothesize that speech understanding will improve when the FV is the target, and that the opposite will be true when the FV is the masker, because the familiar talker will draw attention away from the unfamiliar target voice. Further, we hypothesize that errors in speech understanding will be dependent on the role of the FV (target vs. masker) and its spatial location relative to the other voices in the scene, and that these effects will be modulated by listener age.

Design: A total of 30 adults (18-80 years old) who are familiar partners and who have cohabitated for at least 1 year are being recruited into the experiment. Participants are screened for normal hearing sensitivity and cognitive awareness. Sentences from the Boston University Gerald (BUG) speech corpus are used as the stimuli. Each participant records a unique subset of sentences that are presented as the FV for their partner, and as an unfamiliar voice for other participants. Listeners are presented with sentences (under headphones) where the FV is either the target or a masker, and are instructed to report what was said through a closed set of word choices. Speech understanding is measured when the target and a single masker are routed to the same ear (monotic), and when the target is presented monaurally and the two maskers are presented dichotically.

Results: Preliminary data suggest that speech understanding performance is best when the target talker is familiar and a single unfamiliar masker is presented in the same ear. In the dichotic conditions, older adults show reduced benefit from listening to a familiar target, as compared to younger adults. Confusions of incorrect responses for each condition show that younger adults are able to suppress a masker in the ear opposite the target talker, whereas older adults are unable to suppress the non-target masker.

Conclusions: The preliminary data indicate that older adults commit more intrusion errors than younger adults when listening in a dichotic configuration. This suggests that older adults may have increased difficulty suppressing competing speech, regardless of talker familiarity, in a complex environment.

TINNITUS

Poster # 93

CBT for Tinnitus: Historical Basis and Current Evidence for Implementation

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Objectives: Cognitive Behavioral Therapy (CBT) is a form a psychotherapy intended to help individuals cultivate skills and strategies to cope with and manage difficult emotions, experiences, and sensations.

Originally developed as a treatment for depression, CBT has since been adapted for treatment of tinnitus, as well as anxiety, post-traumatic stress disorder, obsessive-compulsive disorder, and many other conditions. CBT for tinnitus has been endorsed by the American Academy of Otolaryngology-Head and Neck Surgery Foundation, American Academy of Audiology, and American Speech-Language Hearing Association, as having strong evidence as an effective treatment approach for tinnitus. This approach does not aim to reduce or stop generation of the tinnitus percept, rather it is intended to help diminish the negative functional impact of experiencing tinnitus and thereby improve quality of life. Since tinnitus distress can manifest differently for each patient, CBT for tinnitus seeks to identify and address the situations of greatest concern to the individual. The standard CBT protocol involves six to ten weekly sessions; commonly addressed themes may include developing proper sleep hygiene, relaxation techniques, and responding to inaccurate or unhelpful thought patterns.

Poster # 94

Assessment of Tinnitus Treatment Outcomes with Behavioral and Neural Measures

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Objectives: Audiologists offer various treatment approaches for the management of tinnitus, but little evidence is available to guide them in their selection of a specific sound therapy for an individual patient. Tinnitus management may be informed by a better understanding of the neural mechanisms that are associated with tinnitus perception. This study seeks to identify the factors that contribute to successful tinnitus management and the primary neural mechanisms that underlie perception of tinnitus.

Design: Sixteen adults (ages 18 to 70) with tinnitus and 16 sex-, age-, and hearing-matched adults without tinnitus are being recruited to participate in an initial study to demonstrate efficacy of the approach for evaluating tinnitus outcomes. Both tinnitus and non-tinnitus participants receive comprehensive audiologic evaluations. In addition, click-evoked auditory brainstem responses (ABRs) and auditory steady state responses (ASSRs) at rates of 20, 40, 100, and 200 Hz are recorded in both groups. The tinnitus participants receive comprehensive tinnitus evaluations and are then randomly assigned to one of two treatment methods for 8-weeks duration, followed by an additional 8 weeks of the other treatment. ABR and ASSR amplitudes are compared between the tinnitus and non-tinnitus groups. A factorial design will be used to evaluate effects of the two tinnitus treatments. Linear regression will be used to determine the factors that contribute to successful tinnitus outcomes.

Results: Preliminary data show lower ABR Wave I and higher Wave V amplitudes in tinnitus (N=7) compared to non-tinnitus (N=7) participants. The phase-locking factor for the 40-Hz rate was lower in tinnitus compared to non-tinnitus participants, but no differences were noted at any other rates. The Wave V amplitude was negatively correlated with 40-Hz phase locking. Tinnitus treatment is ongoing.

Conclusions: The higher Wave V amplitudes in the tinnitus participants suggest increased neural excitability in the rostral brainstem to compensate for reduced afferent input (lower Wave I amplitudes). However, reduced phase locking to the 40-Hz rate suggests lower levels of cortical neural activity in tinnitus compared to non-tinnitus participants. Further analyses will be conducted as participants complete treatment protocols.

ANATOMY and PHYSIOLOGY

Poster # 95

Role of Nucleoside Transport in the Mammalian Cochlea
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Objectives: The mammalian cochlea contains sensory hair cells that do not proliferate (divide) or regenerate. Therefore, the set of cochlear DNA material that a given individual is born with, is expected to last the entire life-time of the individual. This is particularly relevant to sensory hair cells and has served as one of the bases for effort to regenerate hair cells. We tested the hypothesis that the DNA material within mammalian hair cells can be replenished through nucleoside transport pathways.

Design: As a first approximation to resolving this hypothesis, we conducted a series of experiments to target and interrupt the nucleoside transport pathways of hair cells. The single chain fragment from the 3E10 monoclonal antibody (Fv) was used to specifically design a construct that directly targets DNA in the extracellular mileu. This construct was annealed to a recombinant fusion protein (heat-shock-protein-70) to form an Fv-Hsp70 holocomplex.

Results: Administration of this holocomplex into the cochlea to block DNA material from entering hair cells resulted in significant loss of hair cell function.

Conclusions: The combined results suggest that mitotically inactive cells such as hair cells may nonetheless undergo significant anabolism and catabolism of their DNA and such reactions are critical to the functional integrity of the cells.

Poster # 96

Laterality of Cortical Auditory Structures: Schizophrenic Subjects vs. Normal Controls
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Objectives: Auditory verbal hallucinations (AVH), or internally generated perceptions of speech that occur in the absence of external auditory stimuli, are one of the most common sequela of individuals diagnosed with schizophrenia; occurring in 70% of patients. The cortical auditory structures, namely planum temporale (PT) and Heschl's gyri (HG), have been proposed as potential neurobiologic underpinnings of AVH. One of the most replicated morphometric findings is that patients with schizophrenia who experience AVHs exhibit structural and functional abnormalities of typically left lateralized cortical auditory structures. Specifically, these patients have demonstrated either an abnormal right>left volumetric asymmetry or abnormal interhemispheric volumetric symmetry (right ≈ left) between homologous cortical auditory structures. This is supported by auditory electrophysiologic studies that have demonstrated reduced left P300 and left mismatched negativity responses, whose neural generator sites also arise from the posterior superior temporal plane. Although there are various studies evaluating volumetric laterality of cortical auditory structures in schizophrenic patients with AVH, there are limited studies that focus on laterality of surface area measurements; and even fewer that have used modern 3D morphometric analysis techniques. The purpose of this study is to compare the laterality of cortical auditory surface area measurements between a group of patients diagnosed with schizophrenia who experience hallucinations and a neurologically normal control group. It is hypothesized that the schizophrenic group will have right-favoring laterality indices of cortical auditory structures compared to the normal control group.

Design: High-resolution MRI brain scans of 37 right-handed adults (mean age = 22.38) diagnosed with schizophrenia were compared to age matched normal controls. Images were obtained from the NUSDAST and OASIS open access neurorepositories. Automated cortical reconstruction processes were implemented, including: skull-stripping, 3-dimensional cortical surface rendering and cortical parcellation. BrainVisa Anatomist neuroimaging software was used to define virtual clipping planes that exposed PT, HG and STP. Regions of interest were digitally and manually outlined. Subsequent surface area measurements were obtained by using a custom PYTHON script and the laterality index was calculated using [(L-R)/ 0.5(L+R)].

Results: There were no statistically significant differences between group LI's for any of the examined neuroauditory substrates [F(1,65) = 0.47 , p = .47], even when total intracranial volume, age and sex were controlled for as covariates. However, the schizophrenic group exhibited a greater proportion of occurrence of right>left asymmetries for STP and PT 〖(X)〗^2=(2,N=74)=5.63, p<.05,"ϕ=0." 30).

Conclusions: Interestingly, the schizophrenic group did not exhibit the abnormal right> left asymmetry of cortical auditory structures found in previous studies. Although group differences in mean LI across the cortical auditory regions was non-significant, there was still a statically significant greater proportion of schizophrenic brains that exhibited right>left reverse asymmetries for the STP and PT. Abnormal right> left asymmetries found in previous studies may depend more on cortical thickness and should be examined in conjunction with surface area measurement to examine how much each contribute to the overall volumetric measurements. Whether these differences are clinically correlated to degree and frequency of auditory hallucinations remains unknown and is also the focus of future studies.

Poster # 97

Effective Medications for Recovery of Threshold Shifts in Acoustic Trauma

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Objectives: Although various treatments for acute acoustic trauma (AAT) had been introduced by many clinical studies, there was a lack of articles which reported the amount of recovery in terms of the hearing thresholds when those therapies were applied, especially to humans. In this light, the purpose of the present study was to find the most effective medications to cure the AAT in the threshold recovery while using a systematic review and meta-analysis technique.

Design: As the first approach, we searched articles related to medication effects of AAT by using seven electronic databases. Five main headings related to the study purpose were applied to find 6,244 articles published from 1995 to 2019. After removing 2,011 duplications, 4,233 articles remained. While using our inclusion criteria, i.e., participants, intervention, control, outcomes and study design (PICOS), either abstract or full-text of the articles was evaluated by two authors independently. Finally, a total of 15 articles were applied for the study quality and meta-analysis. The standardized mean difference was performed as the hearing threshold changes at the commonly reported frequencies such as 2, 4 and 8 kHz before and after treatments, and the weight of each study was calculated by study design, medicine, and treatment effect. A Higgins I2-statistics and Q statistics were used for checking the heterogeneity. A random-effect model was used for assumed to be heterogeneous. If the heterogeneity was high, the meta regression was conducted. To test the publication bias, funnel plots were drawn with Egger's regression.

Results: The mean quality score for the 15 studies were 14.36 (SD: 2.84). Except for one study that evaluated low quality, a total of 14 qualified studies were included for the meta-analysis. In the meta-analysis, we categorized the studies as steroid mono (n=8) and combination (n=6) therapies. The steroid monotherapy showed a similar effect size at each frequency, but the threshold at 2 kHz showed the highest effect size (-0.94, 95% CI: -1.26 to -0.61). Unlike to the low heterogeneity of 4 and 8 kHz ($I2 \leq 22\%$), the thresholds at 2 kHz showed the highest heterogeneity (I2=62%). In combination therapy, 4 kHz showed the highest effect size (-1.16, 95% confidence interval: -1.61 to -0.71) with the highest heterogenous (I2=85%). However, the effect size difference at 2 and 8 kHz of the monotherapy and combination therapy was absent (-0.94, -0.8 vs. -1.02, -0.78). The result of Egger's regression provided that the studies had publication bias ($p< 0.05$).

Conclusions: Based on the current results, the combination therapy showed better improvement than steroid monotherapy in terms of hearing threshold recovery, although both the steroid monotherapy and combination therapy were useful in treating AAT. Specifically, the treatment effect of the combination therapy was noticeably revealed at 4 kHz. The threshold recovery of monotherapy at 8 kHz was slightly better than that of the combination therapy, which might inform to the clinicians.

Poster # 98

Do Heschl's Gyrus Duplications Bias Laterality Measurements in Normal and Schizophrenic Brains?
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Objectives: While less common in the general population, approximately 60-80% of individuals with schizophrenia experience auditory hallucinations. Although it is possible to have hallucinations that affect all of our senses, auditory hallucinations are one of the most common types of hallucinations; they can be described as sensations that occur in the absence of an external stimulus. Auditory hallucinations can vary greatly in terms of complexity, clarity, number of speakers, and other factors. It has been theorized that auditory hallucinations may be related to abnormal processing in the central auditory system, specifically the left auditory cortex. Relatively recent literature has suggested that there may be size differentials between normal and schizophrenic brains with regard to the auditory cortex region. Compared to normal control brains, differences have been found in the gray matter volume of the temporal lobes in individuals with schizophrenia. Given the findings in previous literature, we hypothesized that there would be asymmetry between hemispheres of individual brains regarding the number of Heschl's gyri and the shape of planum temporale. We also hypothesized that the pathologic brains would demonstrate greater asymmetry than the control brains.

Design: This anatomical study is one in a pair of companion studies on morphologic differences between schizophrenic and normal brains. In this study, we investigated the morphology of the superior temporal plane within the temporal lobes of 37 schizophrenic brains (74 hemispheres) and 33 control brains (66 hemispheres). The superior temporal plane is composed of Heschl's gyrus, planum temporale, and planum polare. For this study, we focused on Heschl's gyrus and planum temporale. BrainVisa Anatomist neuroimaging software was used to manually identify Heschl's gyrus and planum temporale. We sorted Heschl's gyrus morphology into three categories (single gyrus, common stem duplication, or complete duplication); similarly, we sorted planum temporale morphology into three categories (pie, trapezoid, or rectangular shape).

Results: Preliminary results suggest that there is no difference in gross morphology of the auditory cortex between pathologic and control brains. However, there are some significant differences between hemispheres of individual brains. There were differences in the morphology of the planum temporale; specifically, the shape of

the planum was different in the schizophrenic brains than in the control brains. Notably, it is more common in schizophrenic brains to have a duplication of Heschl's gyrus (or two Heschl's gyri) in the right hemisphere.

Conclusions: Though these are preliminary results, they raise concerns about current data and interpretation regarding the anatomy of the auditory cortex region in schizophrenic brains.

Poster # 99

Cochlear Immune Activation in Repeated Acoustic Injury

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Objectives: Repeated acoustic overstimulation is a common health hazard in industrial and military settings. Previous studies have shown that a prior history of acoustic injury can affect cochlear responses to subsequent acoustic stress. However, the underlying mechanism is not clear. We previously demonstrated that acoustic overstimulation perturbs the cochlear immune environment. Therefore, we hypothesized that the presence of local immune activation provoked by a prior acoustic injury could prime the cochlear immune system and thus sensitize the cochlea to subsequent acoustic trauma.

Design: Young C57BL/6J mice (n=40) and CX3CR1GFP/+ mice (n=20) with an equal number of males and females were used. CX3CR1GFP/+ mice were created by cross-breeding B6.129P2(Cg)-Cx3Cr1tm1Litt/J with C57BL/6J mice. Mice were randomly divided into 3 groups: naive control group, single noise group (N1), and double noise group (N2). The mice in the noise groups received a broadband noise at 120 dB SPL for 1 hour. The N1 group received the noise exposure once and the N2 group received the noise exposure twice with a 20-day gap. Auditory brainstem responses were measured to assess auditory function before and after the noise exposure. Cochleae were collected at either 2- or 20-days after the noise exposure. Sensory cell damage was assessed using nuclear staining. RT-qPCR and immunohistology were performed to determine the transcriptional and protein expression of inflammation-associated genes, including Ccl2, Tnf-α, Il1ß, Ccl7, and MHC-II. Cochlear macrophages/monocytes were identified with a panel of immune cell markers: CD45, Iba1, F4/80, CD68, and Ly6C. Their number and morphology were analyzed. Moreover, Fluoresbrite Polychromatic Microspheres were used to track anti-inflammatory monocytes in the cochlea. Statistical analyses were performed using SigmaStat and an α-level of 0.05 was chosen to denote significance for all statistical tests.

Results: Compared to the N1 group, the N2 group displayed greater sensory cell damage that occurred between 2- and 20-days after noise exposure. This increase in delayed sensory cell damage suggests that repeated noise exposure preferentially potentiates secondary damage in the cochlea. We also found that exposure to the intense noise at 120 dB SPL for 1 hour activated the cochlear immune response in a time-dependent fashion with substantial macrophage infiltration and activation at 2-days after noise exposure. At the time of second noise exposure, the number of macrophages and pro-inflammatory phenotypes of macrophages significantly subsided but had yet to return to the homeostatic level. Furthermore, monocytes with anti-inflammatory phenotypes were present in the cochlea. In the presence of this residual immune activation, the cochleae sustained with the repeated noise exposure displayed an exacerbated infiltration and maturation of macrophages, suggesting that

prior noise exposure sensitizes the cochlea to inflammation activation upon a future encounter of repeated acoustic overstimulation.

Conclusions: Our study points to the possibility that the cochlear immune system plays an important role in modulating cochlear responses to repeated acoustic stress. Future investigations into the therapeutic effects of pro-resolution mediators for speedy inflammation resolution hold clinical promise for reducing cochlear susceptibility to subsequent acoustic injury.

AUDIOLOGY / OTOLOGY

Poster # 100

Tablet Audiometry
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Objectives: The objectives of this study are to study the efficacy of using a tablet audiometer and to compare the automated play vs. tester assisted test techniques.

Design: Participants were children age 5 to 12 attending after school programs around the greater Lafayette, Indiana area. After otoscopy, each participant was alternately assigned to be administered automated play (a game-based version available on a tablet) or tester assisted audiometry (standard hand raise task) at 500, 1000, 2000 and 4000 Hz using the Shoebox Tablet Audiometer. A total of 68 children participated in the study. In addition to the hearing thresholds for each participant, the following data were collected: 1. Time taken for test instructions 2. Time taken for testing 3. Noise level in the room4.Previous exposure to an iPadData will be analyzed to compare the time taken for the instructions and test procedure for the two methods (tester assisted and automated play). Age and gender comparisons will also be made. Additionally some children were tested with both procedures and same subject variability will be analyzed.

Results: Preliminary results demonstrate that tester-assisted audiometry was significantly more efficient than automated play audiometry for both test instructions as well as for the test procedure. Children required reinstruction or could not complete the task during automated play audiometry more frequently than during tester assisted audiometry.

Conclusions: Tester-assisted audiometry was more time efficient and engaging than the automated play audiometry available on the tablet. For hearing testing outside of a clinical setting, the current game-based play task does not appear to be engaging enough for children ages 5 to 9. Tablet audiometry presents new opportunities for hearing assessment outside of a soundproof booth. These environments include rural/ remote areas, hospitals/ long-term care facilities and annual school/ after school program screenings. It is important to note that this type of test may not be suitable for children who have cognitive delays.

Poster # 101

Longitudinal Analysis on the Association Between Hearing Loss and Falls
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Objectives: Emerging evidence shows that hearing loss is independently associated with an increased risk of falls. Moreover, as the severity of the hearing loss increases, the odds of falling also increases. Our objective was to 1) investigate the odds of falls when hearing was self-rated, and 2) explore whether hearing aid use modifies odds of falls in older adults with self-rated hearing impairment.

Design: The Health and Retirement Study (HRS) is a publicly available survey-based longitudinal study of approximately 20,000 older American adults. The participants are surveyed every 2 years. HRS collects data on the participants' health, health services, labor force, economic status, family structure, expectations, etc. We evaluated older adults (65 years of age or older) over seven survey cycles (2004 - 2016). An individual's time of entry into our analysis was when they reached the age of 65 years and all subsequent cycles were included. We evaluated hearing impairment status, hearing aid use, and falls history. We controlled for demographic and health related variables. Logistic regression was used to evaluate the odds of falling. Sankey plots were used to visualize and explore the trajectory of odds of falling longitudinally as a function of age and hearing status.

Results: A total of 17,923 individuals were included in the analysis. At time of entry into the study, 14.5% endorsed excellent hearing whereas, 24.9%, 35.9%, 17.9%, add 6.7% stated they had very good, good, fair, or poor hearing, respectively. A total of 32.8% of individuals reported a fall during the two years prior. Only 3.1% of the sample reported hearing aid use. Logistic regression results showed that hearing impairment was associated with increased odds of falling. In addition, there was a dose-dependent association between self-reported hearing loss and self-reported falls. Compared to those who rated their hearing as "excellent", individuals who rated their hearing as "very good" had a 7% increased odds of falling, whereas, those individuals who rated their hearing as "poor" the odds of falling increased by 43%. When we allowed the association to differ by hearing aid use (i.e., inserted the hearing aid use variable as an interaction term in the model), the fully adjusted model was not statistically significant different ($p = 0.11$) indicating that hearing aid use did not have an impact on the association between hearing loss and falls.

Conclusions: Using longitudinal data, our findings show as the degree of hearing loss increased so did the odds of falling. Our findings provide additional confirmatory evidence to prior research that used audiometric threshold data to demonstrate a dose dependent association between hearing loss and falls. When evaluating whether hearing aid use modified the odds of falling, we found no statistically significant difference on the odds of falling for hearing aid users and non-users. Our findings would suggest that further work is needed to understand potential mechanisms that explain the link between hearing loss and falls is necessary to develop treatment strategies to reduce the risk of falling. Limitations and future directions will be discussed.

Poster # 102

The Component Structure of the Dizziness Handicap Inventory : A Reappraisal

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Objectives: The Dizziness Handicap Inventory (DHI) is a 25-item self-report questionnaire developed to measure the disabling and handicapping impact of dizziness. The present investigation was conducted in an effort to re-assess the factor structure of the DHI.

Design: Exploratory factor analysis: an exploratory bifactor analysis (EFA) with bifactor rotation was used to analyze a random sample of 999 patients. Analyses were used to determine the dominance of the general factor (i.e., total score) relative to the group factor (i.e., subscales). Confirmatory factor analysis: a confirmatory bifactor graded response model was fit with appropriate item-to-group relationships that was discovered by our exploratory analyses. To validate the bifactor model that was identified with the exploratory analyses, a bifactor model with three grouping factors (i.e., Physical manifestations, Catastrophic impact of dizziness, and the Emotional impact of dizziness) were fit to a different random sample of 992 patients using the new item-to-group factor specifications.

Results: In the confirmatory analyses, all items had a positive factor loading on the general factor. There were 14 items that loaded on the general factor only. The rest of the items (n=11) loaded on both the general factor and one of three group factors.

Conclusions: Conclusions of the study revealed several findings: 1) reporting the result as a total score (i.e., a single general factor) is warranted, and, 2) there is statistical support for the existence of three subscales representing: the Physical manifestations, Catastrophic impact, and Emotional impact of dizziness and vertigo.

Poster # 103

Complications following Surgery in Older Patients with Hearing Loss

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Objectives: In older patients, untreated hearing loss has been associated with higher rates of hospitalization, mortality, and cognitive impairment. To date, no studies have examined postoperative complication rates in those with hearing loss and whether a dose-effect response exists between degree of hearing loss and postoperative complication rates. We hypothesize that hearing loss is associated with higher rates of postoperative complication. We also hypothesize that there will be a dose-effect response such that those with greater degrees of hearing loss will have higher risk of having a complication.

Design: This was a retrospective cohort study that used merged datasets from Pythia and Audbase. Pythia is a comprehensive and curated surgical data repository. The database contains patient electronic health record data from all surgeries at our institution. Audbase contains audiometric data of all patients seen in Audiology clinic at our institution. The databases were established in 2014 and 2009, respectively.Patients 65 years of age or older who underwent a major surgery and who had an audiometric evaluation prior to surgery were included in our cohort. Otologic surgeries were excluded. If a patient had multiple surgeries, then only the first surgery was considered. Patients were classified as having either normal hearing (≤ 25 dB HL) or hearing loss (> 25 dB HL)

based on the pure-tone average of .5, 1, 2 and 4 kHz in the better ear. Patients with an audiogram with reliability less than “good” were excluded. Surgical complications were defined by a set of 271 ICD codes occurring within 30 days following the surgical procedure. A binary variable, “any complication”, was created based on the occurrence of any of these diagnoses.

Results: Pythia contains 15,475 patients 65 years or older who underwent 18,466 major surgeries between the dates of January 1st, 2014 and January 31st, 2017. Of these surgical cases, 606 unique patients had audiometric data (184 with normal hearing and 422 with hearing loss). Complications were documented in 23.9% (44/184) and 39.6% (167/422) in these groups, respectively. A Chi-Square test of independence demonstrated an association between hearing loss and whether a surgical complication occurred, Œß2 (1) = 13.85, p< .001. Older patients with hearing loss had a higher odds of developing a postoperative complication compared to those without hearing loss (unadjusted odds ratio 2.08). Additional analyses will be conducted and will include evaluation of a potential dose-effect response between degree of hearing loss and postoperative complications while adjusting for age, gender, race, and medical comorbidities.

Conclusions: Preliminary analysis showed that surgical complication rates were higher in a cohort of older adults with any degree of hearing loss in the better ear, compared to surgical patients with normal hearing. Hearing loss may be an important factor to consider in the risk stratification of older surgical patients.

Poster # 104

Conducting Audiological Research with Clinical Databases

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Objectives: The goal of this project is to provide insights about the benefits and challenges of conducting research with electronic health records (EHRs) in the field of audiology. This presentation is intended to be a tutorial for researchers interested in working with clinical records.

Design: This presentation utilizes a conceptual framework to discuss the process, benefits, and challenges of working with EHRs in audiological research. The framework describes four stages from patient care to researcher data use, as follows: 1) event occurs, 2) event is recorded, 3) data are extracted and 4) data preparation.

Results: We first present issues that can arise when working with clinical databases for research purposes. Next, we leverage our experience working with an EHR data containing over 730,000 cases from the United States Department of Veterans Affairs (VA) to discuss how we overcame specific issues. By using the framework described above to identify common issues in EHR research, we describe how we were able to overcome many of these issues to establish confidence in this dataset. We do so largely with examples using audiometric data and diagnostic and procedural codes. Finally, we discuss considerations for data interpretation and applications of EHR research in audiology.

Conclusions: There are considerable advantages to working with EHR data, including large sample size, the vast range of variables, and availability of longitudinal diagnostic and treatment information. In audiological research, EHR usage permits examination of associations between health, demographic and audiological

variables and outcomes, and can yield a better understanding of the longitudinal progression of audiological care processes. However, there are challenges to EHR research, including the correct interpretation of results necessitating a deep understanding of the data source and structure and extensive data cleaning and pre-processing. We conclude that EHRs have considerable utility in audiological research, though researchers must exhibit caution and consideration when working with EHRs.

Poster # 105

Examining Force-Level Thresholds with Bone Conduction Hearing Devices

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Objectives: Desired Sensation Level (DSL) prescriptive targets for percutaneous bone conduction hearing device (BCHD) fittings are clinically available as are skull simulators for objective force-level measurements. These tools support the verification of BCHDs beyond measuring behavioural thresholds, which is not compatible with some clinical populations (e.g., infants). Although it is feasible to measure the force-level output of transcutaneous BCHDs using a skull simulator, it is unclear whether modifications to prescriptive targets for percutaneous BCHDs are necessary. The force-level transmission loss across the skin when fitting transcutaneous BCHDs means that the current prescriptive targets for percutaneous devices may not be suitable. It is therefore of interest to investigate the force-level thresholds of various BCHDs and determine their impact on the fitting process. It was hypothesized that thresholds obtained using transcutaneous BCHDs will be higher compared to percutaneous BCHDs and an audiometric bone oscillator.

Design: Fifty-two normal hearing adults were recruited from Western University (N = 20) and the University of Alberta (N = 32). Conductive hearing losses were simulated using E-A-R 3M Classic foam ear plugs for the Western University participants only. Fifteen patients from iRSM who wear percutaneous BCHDs also participated. Thresholds were gathered from all participants using a B71 bone oscillator and various transcutaneous and percutaneous BCHD processors. In-situ thresholds were obtained with each processor using the manufacturer fitting software. The Western University participants (20 with simulated loss) provided preferred listening level (PLL) judgements which were compared to the default fittings derived from the in-situ thresholds. Measured force-level outputs of the default fittings and the PLLs were obtained for comparison.

Results: For all groups in-situ thresholds obtained with transcutaneous BCHDs were significantly higher on average compared to thresholds obtained with the B71 transducer and percutaneous BCHDs in patients. Participants with simulated conductive hearing loss preferred an overall force level similar to the default fitting if the in-situ transcutaneous thresholds were used and frequency shaping followed the current DSL prescriptive targets. Frequency and device differences were noted across all measures.

Conclusions: Contact force and calibration differences between transcutaneous BCHDs and the B71 may account for the observed threshold differences. Circuit noise inherent in BCHDs may also explain some frequency-specific threshold differences. Further work is necessary to consider adjustments to in-situ thresholds obtained with transcutaneous devices for the calculation of DSL prescriptive targets. This will inform fitting protocols for BCHDs.

Poster # 106

Does Personality/Cognitive Profile Predict Perceived Listening Effort in Older Adults?
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Objectives: Researchers have determined that individual factors such as age, performance on cognitive tasks and specific measures of personality traits can be linked to differences in subjective ratings of physical and psychological health, listening outcomes, and success with amplification. In most cases, each of these factors is examined independently against the outcome of interest. Fewer studies have examined how the relationships among these factors might combine to influence how subjective outcomes are reported. This research was designed to explore how combinations of personality traits and cognitive abilities might impact subjective ratings of listening effort in daily life. We hypothesized that participants with high-neuroticism, low-openness, and lower performance on working memory tasks would report more listening effort in daily listening.

Design: Forty-five older adults with bilateral mild-to-moderate sensorineural hearing loss participated by wearing four pairs of bilaterally fitted hearing aids for one month each. Subjective listening outcomes were evaluated at the end of each month's trial. Personality traits were obtained from responses to the International Mini-Markers personality test and cognition was quantified using the Reading Span measure of working memory capacity. The five personality traits and reading span scores were used to form cognitive/personality profiles using a K-means cluster analysis.

Results: Cluster analysis results separated participants into three distinct groups: those with high-cognition and high scores across the five personality traits (Cluster 1; Hi-Cog, Hi-Trait); those with low-cognition and high scores across personality traits (Cluster 2; Lo-Cog, Hi-Trait); and those with high-cognition and low scores across personality traits (Cluster 3; Hi-Cog, Lo-Trait). T-test results showed a significant difference in reported aided listening effort between the Lo-Cog, Hi-Trait Cluster and the Hi-Cog, Lo-Trait Cluster ($p=.012$, $d=0.84$), with the Lo-Cog, Hi-Trait Cluster reporting more listening effort.

Conclusions: These findings supported our hypothesis that individuals with high-neuroticism and lower working memory capacity would report greater effort in daily listening; but was not consistent with the hypothesis that individuals with high-openness would report less listening effort. Personality traits and cognitive ability might influence respondents' decisions about how to answer questions at several different levels, including how they interpret the questionnaires, recall information about their experiences, form judgments, and edit their answers. Although these findings suggest that individuals with lower cognition and higher scores on personality traits might experience greater listening effort, an alternative interpretation might be these individuals tend to report poorer outcomes regardless of the domain. To explore this possibility, different domains of listening outcomes were compared among the groups. These post-hoc comparisons revealed the Lo-Cog, Hi-Trait cluster reported poorer aided speech communication benefit (APHAB Global Score) than the Hi-Cog, Hi-Trait cluster ($p=0.024$, $d=1.19$), and greater problems with aversiveness of amplified sounds than both of the other clusters (Hi-Cog, Hi-Trait, and Hi-Cog, Lo-Trait; $p=0.025$, $d=1.1$; and $p=.047$, $d=0.64$, respectively). These results demonstrate that interactions among individual characteristics can influence subjective reports of listening outcomes. Implications of these effects will be explored.

Poster # 107

Does Tension/Placement of Bone-Conduction Coupling Systems Affect Word Recall?

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Objectives: Non-surgical retention options for bone conduction hearing aids are available for children below five years of age presenting with conductive/mixed hearing loss or single-sided deafness. However, these retention options have limitations in that variability in tension and/or placement of the systems may affect auditory perception. In this study, the effects of variable tension and placement with two commonly used retention systems were evaluated. Word recognition is known to be insensitive to differences in performance across different retention systems. Recalling words perceived through the auditory modality is a commonly used skill in everyday life. It was hypothesized that word recall may be more sensitive than traditional word recognition, to sub-optimal device placement and tension. The primary aim of this study was to assess performance for systematic variations in tension and placement that can occur in daily use with both retention options.

Design: A bilateral mild to moderate conductive hearing loss was simulated in fifteen normally hearing young adults, using E-A-R foam plugs and addition-cured silicone ear impression material. Participants were then fit with the Cochlear® BAHA 5 speech processor coupled to each of two retention systems; the Cochlear Americas® SoundArc and the soft band. The selection of appropriate SoundArc size and the soft band circumference for each patient was guided by the Cochlear ® fitting guidelines. In addition to the optimal fitting condition, three additional fitting conditions were created for each coupling system, resulting in a total of eight conditions. Specifically, tension was varied by using a larger sized SoundArc and by increasing the soft band diameter from one to four fingers inserted under the band. Placement was varied by shifting the device two inches below the optimal position. Word recall was assessed in each of these conditions using the Rey Auditory Verbal Learning Test (RAVLT). Eight counterbalanced word lists were used for each of the conditions, with three repetitions/trials completed for each list.

Results: As expected, word recall improved significantly with each repetition of words for each retention system. No significant effect of placement occurred for either retention system across repetitions. However, a significant effect of tension was observed. Specifically, recall improved as tension increased with the soft band and was 20% higher than the recall achieved with the SoundArc which showed no effect of tension. These results indicate that daily auditory tasks like recalling simple words are optimized by proper tension. Also, because higher overall performance was achieved with the soft band than with the Sound Arc, the ability to achieve the proper tension varies across fitting systems.

Conclusions: These findings highlight the importance of proper tension during fitting of bone-conduction systems to achieve optimal auditory benefit. To that end, improper tension of either of these fitting systems, either during the fitting process or during everyday use, may be measurably detrimental to the user's everyday listening experience. It is thus important for clinicians and users to achieve and maintain sufficient tension of the coupling system.

Poster # 108

Auditory Phenotype of Spinocerebellar Ataxia Type 7

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Objectives: Spinocerebellar ataxia type 7 (SCA7), is a rare, autosomal dominant, neurodegenerative disorder resulting from abnormal CAG repeat expansion in the ATXN7 gene. Onset ranges from infancy to the fifth or sixth decade of life. Clinical characteristics include progressive cerebellar ataxia and cone-rod dystrophy that can result in blindness. Neuropathology studies reveal neuronal degeneration, loss of myelinated fibers, and gliosis primarily in the cerebellum, but also in the brainstem, midbrain, and thalamus. Given the location of pathologic manifestations, we hypothesized that the auditory system would be affected. Specifically, we sought to characterize the peripheral and brainstem auditory phenotype of persons with SCA7.

Design: Sixteen individuals (12 females) aged 18-63 years with genetically confirmed SCA7 were seen prospectively for auditory evaluation that included pure tone thresholds, distortion product otoacoustic emissions (DPOAE), tympanometry, acoustic reflexes, and neurodiagnostic auditory brainstem response (ABR) testing. All participants were enrolled in an IRB approved observational study of SCA7 and participated in auditory testing during a multi-day comprehensive diagnostic visit to the NIH.

Results: Pure tone audiometry showed mild to moderate sensorineural hearing loss (4F PTA>25 dB HL) in 6 persons (37.5%). Tympanometry was essentially normal in all patients. Acoustic reflexes were absent or elevated in 4 persons (25%). DPOAE findings were consistent with pure tone thresholds and suggested a cochlear origin of threshold elevation. Neurodiagnostic ABR testing showed 8 individuals (50%) with grossly abnormal ABRs, characterized by largely dyssynchronous waveforms and absent wave V in all cases, indicating abnormal function of the auditory brainstem pathway.

Conclusions: To our knowledge, audiology findings are published for just one individual with SCA7 who had bilateral high frequency hearing loss (type not specified), abnormal ABR and abnormal performance on the SSW and gap detection. Our cohort data extend and support the presence of auditory dysfunction in persons with SCA7. Peripheral hearing loss appears to be a characteristic of SCA7, and in the setting of reduced vision, it is important to identify and provide any indicated auditory intervention. We observed abnormal ABRs in 50% and elevated or absent acoustic reflexes in 25% of our cohort; these findings are consistent with the known neuropathology of this disease. Future study of the auditory function should include assessment speech recognition in noise and evaluation of middle and late auditory evoked potentials.

Poster # 109

Hearing and Communication Deficits in Service Members with Normal Audiograms

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Objectives: Deficits in auditory processing (AP) in individuals with relatively normal audiometric thresholds are known to be associated with military risk factors such as blasts and excessive noise exposures. Some DoD and VA service members (SMs) seek clinical services because of perceived cognitive difficulties with memory, concentration, attention, language processing speed, multitasking and word finding. SMs with blast-exposed TBI may also seek counseling for depression and anxiety, as well as auditory problems such as tinnitus and difficulties understanding conversations in noisy settings. Many of these SMs are seen at the Audiology and Speech Pathology Center (ASC) at Walter Reed National Military Medical Center, but a much larger group of active-duty SMs exposed to many of the same military risk factors do not seek clinical services. Instead, these SMs are seen for annual hearing screenings at Occupational Audiology (OA) and are cleared of any suspected abnormalities by virtue of their pure-tone audiogram alone. This study reports on the efficacy of numerous

clinical tests and self-assessment instruments for both groups of SMs, those that seek and those that do not seek clinical services, for predicting functional hearing and communication deficits. In addition, factors such as TBI and PTSD are examined for their potential impact on test scores.

Design: Data from roughly 4000 SMs with normal to near-normal hearing thresholds seen for annual hearing screenings and 200 clinic patients seen at the ASC for suspected AP deficits were analyzed. Outcome metrics in the clinic population included tests of binaural integration, temporal resolution, temporal sequencing, monaural low-redundancy, dichotic listening, speech intelligibility (especially with time-compressed speech), and subjective surveys. Outcome metrics in the OA screening group included tests of binaural integration, speech intelligibility, and subjective surveys of perceived hearing difficulties. Data sets across the two groups matched in age and hearing thresholds using common outcome metrics were analyzed and compared.

Results: Results indicate that behavioral measures of speech intelligibility, binaural integration, and self-perceived difficulties in hearing persist across the two groups after matching for age and hearing thresholds. These differences are most likely due to the comorbid influences of TBI and PTSD that are more prevalent in the clinic population. Further, performance on a large battery of tests for evaluating potential AP deficits performed in the clinic are clearly influenced by the presence of comorbidities such as TBI and PTSD making the interpretation of AP test results much more difficult when determining if abnormal performance is attributed to an AP disorder or to the pre-existing comorbidity.

Conclusions: SMs with Blast, TBI, and PTSD comorbidities exhibit poorer performance on hearing and speech tests that require the integration of information across ears and the ability to segregate speech from background noise, especially if the speech is presented at a fast rate. Comparisons among normal-hearing SMs seeking clinical support for self-perceived hearing problems and those that do not seek clinical services appear to be largely driven by factors associated with PTSD and TBI.

Poster # 110

Wideband Acoustic Reflex Growth in Aminoglycoside-Exposed Adults with Cystic Fibrosis

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Objectives: Cystic fibrosis (CF) is a genetic disorder that causes changes to body secretions including sweat and mucus. Patients frequently experience breathing difficulties and potentially life-threatening infections as thickened mucus clogs airways and traps bacteria in the lungs. Severe lung infections are treated with intravenous (IV) antibiotics including aminoglycosides (AGs) like tobramycin and gentamicin. These drugs have known ototoxic effects, causing sensorineural hearing loss and other inner ear symptoms. Animal data suggest that in addition to damaging cochlear hair cells, AGs may cause cochlear synaptopathy and/or damage to neural mechanisms in higher auditory brainstem structures before a measurable decline in hearing thresholds. AGs can also damage the medial efferent olivocochlear system, causing a lack of suppression of the outer hair cells. The acoustic reflex growth function (ARGF) has been proposed as a non-invasive, objective measure of neural dysfunction in the auditory system. A shallow ARGF has been associated with synaptopathy after noise exposure in rodent and human studies. However, there is a lack of research on this effect in subjects with

exposure to ototoxic drugs. We hypothesized that a finding of shallow ARGF in AG-exposed participants would be consistent with cochlear synaptopathy, and a finding of enhanced reflex growth with AG exposure might indicate a lack of suppression caused by damage in the efferent system at the level of the brainstem or higher.

Design: We examined the wideband (WB) ARGF in 90 normal-hearing participants with and without CF. The CF group was classified by lifetime aminoglycoside exposure based on EPIC chart review. 16 subjects with CF had no IV AG exposure, 23 subjects had 40 doses or fewer, and 22 had over 40 doses. 29 control subjects were age- and sex-matched to the CF subgroups. Procedures included pure-tone audiometry at standard and extended high frequencies, 226-Hz clinical immittance including tympanometry and ipsilateral acoustic reflex testing, and a wideband acoustic immittance battery of absorbance tympanograms, ipsilateral wideband acoustic reflexes, and transient-evoked otoacoustic emissions (TEOAEs). WB reflexes were detected by calculating the shift in absorbed sound power in response to the activator signal. TEOAEs were measured using a double-evoked WB chirp stimulus and one-half octave signal-to-noise ratios (SNRs) were obtained at frequencies from 0.7 to 8.0 kHz. Mean ARGFs were compared by plotting the cumulative absorbed power shift as a function of elicitor stimulus level. TEOAE results were compared by plotting the SNRs as a function of frequency.

Results: CF subjects with highest lifetime IV AG exposure had a steeper ARGF compared to controls, indicating a stronger reflex response. The TEOAE results showed a pattern in the opposite direction of the ARGF, where the group with highest lifetime IV AG exposure had the lowest SNR.

Conclusions: These results diverge from the pattern of ARGF observed in studies of noise-induced synaptopathy and suggest a different mechanism of auditory dysfunction for aminoglycoside ototoxicity. The TEOAE comparison suggests that the ARGF results cannot be explained by peripheral structures alone, and may indicate damage to the efferent system due to ototoxic effects on the brainstem or higher structures.

Poster # 111

Test-Retest Reliability of the Dizziness Symptom Profile (DSP)

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Objectives: The Dizziness Symptom Profile (DSP) developed in 2019, is a 31-item patient self-report questionnaire that was developed in an effort to assist primary care providers, general otolaryngologists and other health care providers in the development of a differential diagnosis for patients who present with dizziness, vertigo, or unsteadiness. The DSP yields a score, ranging from 0 - 100%, for 7 subscales, each representing a differential diagnosis. Device validation was carried out during the development study. Device reliability was evaluated in the current investigation. The purpose of this study was to assess the internal consistency reliability and test-retest reliability of the DSP subscales and the individual items.

Design: Subjects were 150 adult patients (mean age 56.79 years, sd 15.69 years) referred to the balance disorders clinic at Vanderbilt University Medical Center. Subjects completed two administrations of the DSP so that test-retest reliability and internal consistency reliability could be assessed. The first test administration and the second test administration were scored independently. The mean interval between test administrations: 1.57 days (sd 1.79 days). The response mode for the original DSP was a 5-point Likert scale where the anchors were

"strongly disagree" (scored zero points) and strongly agree (scored 4 points). In an effort to increase the range of possible responses to each item, the original response mode was modified to be a 100 mm visual analog scale (VAS).

Results: Interclass correlation coefficients (ICC) and their 95% confidence intervals were calculated to assess test-retest reliability of the individual items. The mean correlation coefficient was 0.80 and the range of correlation values were from 0.67 - 0.91. Cronbach's α coefficient was calculated to assess internal consistency reliability for each of the 7 differential diagnosis subscales. Each subscale had an acceptable level of internal consistency (Cronbach's α coefficients > 0.7) with the exception of Persistent Postural-Perceptual Dizziness (PPPD; Cronbach's α coefficient 0.67-0.68 for each administration). Intraclass correlation coefficient estimates and their 95% confidence intervals were also calculated to assess the relative reliability of the subscales. All 7 subscales showed good to excellent levels of test-retest reliability, with ICCs ranging from 0.85 to 0.94. Minimal detectable change scores were calculated to assess absolute variability/measurement error for the 7 subscale scores (which range from 0 – 100%). Scores ranged from 16% change (PPPD) to 25% change (unsteadiness) to be considered a significant change between tests.

Conclusions: The test-retest reliability for the individual items comprising the DSP is good-to-excellent, and the test-retest reliability for differential diagnoses subscales is excellent. Minimal detectable change (MDC) values have been determined for each differential diagnosis subscale to identify statistically significant changes in each subscale between test administrations.

Poster # 112

Factors for Health Disparities and Prevention Strategies

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Objectives: According to World Health Organization (WHO), hearing health disparity is correlated with the community/country resources and parents' education levels. Additionally, 75% of the hearing loss in low-income countries and 50% in high income countries are avoidable. The objectives of this study were to examine factors associate with the prevalence of ear and hearing disorders found in three regions and 6 microregions of Brazil which are marked by differences in the availability of general resources, and to recommend prevention strategies to improve hearing health.

Design: More than 1500 children ages 3-18 years were tested in seven school at Bauru and Boraceia in the State of Sao Paulo, Joao Pessoa and Macaiba in the Northeast, and Calama and Montenegro in an Amazonian State. Children's outer, middle, and inner functions were examined using otoscopy (Welch Allyn), tympanometry (EroScan Pro), acoustic reflexes (EroScan Pro), and distortion production otoacoustic emissions at 1.5, 2, 3, 4, 5, and 6 kHz (EroScan Pro). If they did not have otoacoustic emissions with signal-to-noise ratios ≥6 dB present

at four frequencies or more, they were tested with play or standard pure tone audiometry at .5, 1, 2, and 4 kHz (EarScan). Children older than 7 or 8 years were also tested at 0.25, (6), and 8 kHz. EarScans were portable audiometers used to test children's pure tone audiometry. They were calibrated to meet the standards of American National Standards Institute during each week of testing. The EroScan Pro units were calibrated within 4 months of testing by the manufacturer. The overall pass and referral rates, the prevalence of different ear and hearing disorders were analyzed and correlated with community characteristics such as availability of audiology services, general social economic status of residents, educational level of parents, family income, and community crime rates.

Results: Preliminary analysis of the results showed that children with highly educated parents tend to have less ear and hearing disorders (e.g., ~20%). Children living in communities with higher crime rate tend to have higher referral rates for ear and hearing disorders (e.g., a school located at a community with high crime rate had a referral rate of ~40%). Additionally, using the criteria of having accumulation of ear wax blocking ≥75% of ear canal ear as the criteria for professional cerumen management, the presence of ear wax was the most prevalent condition among the children (e.g., one school had 34 out of 95 children tested needing services). Middle ear disorder ranked the second most prevalent condition for referral. The prevalence of sensorineural hearing loss was generally below 5%.

Conclusions: Parents/caregiver children need to be equipped with the knowledge of monitoring the ear wax in their children to prevent this highly avoidable condition from inducing hearing loss. Flu vaccines and strategies to improve upper respiratory health may also improve hearing health among Brazilian children.

Poster # 113

Feasibility of Delivering Hearing Healthcare in Non-Traditional, Point-of-Care Settings

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Objectives: Timely diagnosis and intervention are considered necessary for successful rehabilitation of individuals with hearing loss. However, the overall shortage of audiologists and the trend for providers across all health fields to practice in metropolitan areas, increases the likelihood that patients in rural communities will not receive needed care. This study evaluated the feasibility of determining hearing status using automated hearing measurement devices in non-traditional settings.

Design: Complimentary pure tone auditory thresholds were measured at the Minnesota State Fair research facility for willing volunteers. Participants also completed a brief survey of their attitudes and preference for receiving diagnostic audiology services. An automated hearing screener by Creare and an automated diagnostic hearing measurement system by Kuduwave. Accuracy of auditory pure tone thresholds was assessed using test-retest reliability measures that compared automated thresholds with manual audiometry thresholds.

Results: Normal and abnormal thresholds were obtained in the research laboratory as well as in real-world settings. Direct comparisons between the automated thresholds and standard, manual audiometry results showed some agreement in certain frequency regions as well as some areas of discrepancies.

Conclusions: This study provided information that will be used in the development of a connected eHealth system that seek to improve access to and utility of hearing healthcare services. Our results demonstrate the feasibility of leveraging automation and hearing healthcare practitioner skills to help improve the efficiency and possibility of enhancing access to hearing healthcare services for individuals in geographically isolated locations.

Poster # 114

Development of a Protocol to Assess the Client's Audiological Needs Assessment in Audiology: A New Protocol and Clinical Tool

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Objectives: Background: Needs assessment is an important part of the audiological evaluation. However, what constitutes a comprehensive evaluation of needs remains unclear.Objective: To develop a protocol and a clinical tool to assess the audiological needs of individuals with hearing loss.

Design: Methods: Based on the existing literature and on the International Classification of Functioning, Disability and Health (ICF; 2001), an initial draft of a needs assessment protocol was developed. The document was submitted to a panel of 14 expert audiologists, including representatives from the University of Montreal School of Speech-Language Pathology and Audiology, Quebec College of Speech-Language Pathologists and Audiologists, Quebec Association of Speech-Language Pathologists and Audiologists, Regie de l'assurance maladie du Quebec, Ministry of Health and Social Services, and an association of persons with hearing loss. Once revised by the expert panel, the protocol was discussed (individual semi-structured interviews) with 14 audiologists who worked in public and private settings. The interviews served to explore the applicability of the needs assessment protocol in a clinical setting. Based on the results of the interviews, a final version of the protocol was devised. In addition, a clinical tool (a questionnaire based on the needs assessment protocol) was developed.

Results: The needs assessment protocol covers the following areas: 1- Audiological needs (activity limitations, participation restrictions, and environmental factors), 2- Living conditions (social networks and living environment), 3- Personal factors (motivation, dexterity, cognition, etc.), 4- Discussion with the client concerning the goals of the treatment program and the intervention strategies retained for each goal, and 5- Recommendations. The protocol and the clinical tool will be presented in detail during the conference.

Conclusions: A research project is currently underway to assess the psychometric properties of the clinical tool as well as to evaluate the applicability of the protocol in clinical settings.

COCHLEAR IMPLANTS

Poster # 115

Role of Semantic Context and Talker Variability on Cochlear-implant Outcomes

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Objectives: Much variability exists in the speech perception abilities of cochlear-implant (CI) users that cannot be explained by clinical or anatomical factors. In this study, our aim was to assess the impact of semantic context and talker variability on speech perception for CI users and compare the variance in performance across conditions with normal-hearing (NH) listeners under vocoded conditions. We hypothesized that performance for CI users would suffer significantly when semantic context was absent and that talker differences may also mediate this effect. We also anticipated that performance for age-matched NH listeners under vocoded conditions would be more variable than that of younger NH listeners and perhaps as variable as performance for the CI group.

Design: Thirty post-lingually deafened adult CI users were tested on word intelligibility in sentences with and without semantic context, presented in quiet and noise, recorded by four different talkers. Thirty age-matched and 30 younger NH adults also participated, listening via tone-excited vocoders, adjusted to produce mean performance for speech in noise comparable to that of the CI group. Overall performance between groups and variance within groups were compared.

Results: Preliminary data suggest that both semantic context and talker variability influence speech perception in CI users, with differences in the speech production of individual talkers sometimes having a greater impact on overall performance. The within-group variance in speech understanding for the age-matched NH group was also greater than that of the young NH group and similar in magnitude to that of the CI group for many of the conditions tested.

Conclusions: These data highlight the potential importance of central factors, not unique to the CI population, in explaining individual differences in hearing outcomes of CI users. Understanding how these factors affect speech perception could help inform auditory rehabilitation in CI users by improving listening strategies used in everyday life.

Poster # 116

Prosodic and Semantic Cues for Emotion Recognition with Cochlear Implants

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Objectives: Emotion in spoken language is conveyed through both prosodic cues (vocal pitch, timbre, loudness, speaking rate, etc.) and semantic cues (lexical meanings of the words in our utterances). In cochlear implant (CI) users, both semantic and prosodic cues are degraded; however, the degraded prosodic cues may be harder to overcome. For normal hearing (NH) listeners, previous research and shown a dominance for prosodic cues in emotion recognition. The purpose of this project was to examine NH listeners' relative reliance on prosodic and semantic cues to emotion in spectrally degraded speech, and investigate the weighting of prosodic and semantic cues for emotion recognition in adult CI users attending to undistorted speech.

Design: Participants included 17 young adult normal hearers (age 19-35) and 8 post-lingually deafened adult CI users (Age 19-75). For this project, new stimuli were developed. Sentences were created to convey 5 semantic emotions (Happy Scared Neutral Sad and Angry). Each semantic emotion category included 5 sentences, each of which was recorded by two female talkers in the same 5 prosodic emotions. Thus, for each recording, prosodic and semantic cues to emotion were either congruent (i.e., the prosodic and semantic emotion were the same), or incongruent (i.e., the prosodic and semantic emotion were different). The sentences were processed to have 3 different conditions of spectral degradation: full spectrum, 16 channel noise-vocoded and 8 channel

noise-vocoded with the same parameters. One semantic sentence recorded in all 5 prosodies for each semantic emotion category was separated out to be a part of a practice block, resulting in a practice block with 25 sentences. The remaining 100 sentences were used as stimuli in test blocks organized by degree of spectral degradation. Each block was presented twice in testing. The order of the test blocks was randomized in testing, but the participant always started with the practice block which contained only full-spectrum sentences. Emotion identification was measured in a single-interval, 5-alternative forced-choice procedure. Percent correct scores were computed, where the "correct" choice was based on the semantic emotions in the stimuli.

Results: The results of the study showed a significant interaction between hearing status (NH vs. CI) and congruency. CI users demonstrated increased reliance on lexical-semantic cues for emotion recognition in the incongruent conditions compared to the congruent conditions. NH listeners demonstrated strong reliance on prosodic cues in both congruent and incongruent conditions in the full-spectrum condition, but increased reliance on lexical-semantic cues for emotion recognition for the incongruent conditions under spectral degradation.

Conclusions: The results of this study indicated that even though prosody was the dominant cue for spoken emotion, NH listeners showed an increasing reliance on semantic cues as spectral degradation became more severe. Consistent with these findings, CI users showed a greater dependence on semantic cues and reduced dependence on prosodic cues for emotion recognition in the full spectrum condition than the NH listeners. Reduced reliance on prosodic cues implies difficulties in sarcasm perception, which involves resolving prosodic-semantic incongruence.

Poster # 117

Comparing Audiologic Outcomes with the FlexSoft Electrode Array

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Objectives: The objective is to compare audiologic outcomes between groups of FlexSoft, Flex28 and Flex24 recipients. Based on previous reports in the literature, we hypothesize that recipients of the longer FlexSoft array will outperform other recipients of shorter arrays at early milestones post-activation.

Design: Postlingually deafened adults (18 years+), who received Medel Flex24, Flex28, or FlexSoft implants were identified through chart review. Groups were age and hearing history matched. Postoperative speech perception scores, residual hearing levels, postoperative dizziness, and full insertion rates were compared. Groups of seven were identified for each group at time of preliminary analysis.

Results: In preliminary analysis the FlexSoft group showed larger percent improvement in AZ Bio sentence recognition scores in quiet from pre-op to 1 month post-activation (FlexSoft m=130%, Flex28 m= 106%, Flex24 m=67%), as well as from pre-op to 3 month post-activation (FlexSoft m=143%, Flex28 m=134%, Flex24 m=131%). There were similar rates of incomplete insertion across groups. The majority of Flex24 subjects were electro-acoustic stimulation (EAS) users (67%) while the Flex28 and FlexSoft groups were largely traditional candidates.

Conclusions: Preliminary results suggest that recipients of the longer FlexSoft array had larger rates of early improvement in sentence recognition ability compared to other groups. Further analysis with a larger sample beyond three months will help to illustrate patterns in long-term speech perception outcomes, feasibility of hearing preservation, and implications for postoperative dizziness. Understanding outcome differences with this

electrode portfolio will help guide clinical decisions in electrode choice for traditional cochlear implant candidates.

Poster # 118

Pitch Perception Preserved with Single Sided Deafness and Cochlear Implants
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Objectives: Cochlear implants (CI) distort vocal pitch, destroying the harmonic structure tied to F0 and often not encoding F0 itself. This distortion, along with decreased spectral resolution, likely underlies CI users' difficulties on vocal pitch perception tasks. For individuals with single sided deafness and a CI, using the CI alongside acoustic hearing, may adversely affect these individuals' vocal pitch perception. To determine if this is the case, this study examined the perception of vocal pitch for individuals with single sided deafness and CIs when using their acoustic hearing alone, their CI alone, or both together.

Design: Participants were presented with a series of recordings of a voice singing /a/, where the F0 varied across recordings. They were asked to select from these recordings to recreate the melody for "Happy Birthday." Participants were tested separately with their acoustic hearing ear, their CI ear, or both together.

Results: As expected, the results indicated that the accuracy of the sung contours they created decreased dramatically when using their CI ear alone. Surprisingly, combining the two ears did not degrade accuracy relative to performance with the acoustic ear alone.

Conclusions: This study demonstrates that, for individuals with single sided deafness, adding a CI does not degrade vocal pitch perception.

Poster # 119

Functional Hearing Quality in Preschool-Aged Children with Cochlear Implants
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Objectives: Auditory outcomes in young, prelingually-deaf children following cochlear implantation typically are assessed using traditional audiological examinations in a highly controlled clinic setting. Much less is known about the functional everyday aspects of hearing - how well a child is able to hear different sounds in different settings in the context of daily life. Self-report everyday functional hearing measures such as the Speech, Spatial, and Qualities of Hearing (SSQ) questionnaire are valuable for evaluating the functional hearing of adults but are not appropriate for very young children. This study aimed to develop a parent-report measure of functional hearing quality (the Quality of Hearing Scale, QHS) for preschool-aged children following cochlear implantation, in order to better characterize auditory outcomes following implantation.

Design: Samples of 26 children with normal-hearing (NH) and 20 children with cochlear implants (CIs) between ages 3 and 6 years were administered the Quality of Hearing Scale (QHS), a new 21-item parent-report questionnaire of child functional hearing quality. Children also completed measures of speech perception, language, and nonverbal intelligence. Information on hearing history, audiological exams, and everyday language comprehension was obtained from parents and clinic charts.

Results: QHS scores showed adequate to strong internal consistency for 4 subscales (Speech, Localization, Sounds, and Effort) and one composite (Hearing Quality; based on Speech and Sounds scores). Children with CIs scored lower than NH peers on the QHS Speech, Localization, Sounds, and Hearing Quality subscales (reflecting poorer functional everyday hearing) and higher than NH peers on the QHS Effort subscale (reflecting more effort in everyday hearing), but raw scores suggested adequate to good everyday hearing in the CI sample. Implantation at earlier ages and longer duration of CI use was significantly correlated with better hearing quality on all QHS subscales. On the other hand, QHS scores were not correlated with best PTA prior to implantation or with most recent aided PTA. In the combined sample, QHS scores correlated significantly in the expected direction with speech perception and language measures but not with nonverbal intelligence. However, correlations between QHS scores, speech perception, and language in the CI sample alone were significant only for parent-reported language comprehension and concept formation.

Conclusions: The parent-report Quality of Hearing Scale (QHS) is a reliable and valid measure of functional everyday hearing quality in preschool-aged children with CIs. Functional hearing quality measured with the QHS was associated with hearing history, speech perception, and language skills, demonstrating that QHS-assessed hearing outcomes are important predictors of downstream speech and language functioning. Importantly, QHS scores were not related to traditional clinical audiological measures, indicating that QHS results add to those measures in characterizing audiological outcomes, particularly regarding daily functioning. Assessment of functional everyday hearing quality using a scale such as the QHS is feasible for preschoolers with CIs, and adds important information to traditional clinical audiological measures in understanding hearing outcomes following cochlear implantation.

Poster # 120

Synchronized Automatic Gain Control for Bilateral Cochlear Implants Can Improve Localization

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Objectives: For bilaterally-deaf listeners with one cochlear implant, numerous benefits have been reported with implantation of the second ear. One common benefit is improved localization of sound sources. Bilateral cochlear implants do not currently encode interaural differences of time and therefore the ITD is an unreliable cue. Therefore, listeners generally rely on interaural level differences (ILD) as a cue for auditory localization. However, this strategy can be compromised by independent automatic gain controls on the left and right Cis that could lead to distorted ILDs. One approach to improving the representation of ILDs would be to synchronize the AGCs at the left and right ears. We tested the localization performance of bilaterally implanted listeners, under conditions where their AGCs were either synchronized or not, in a range of experiments in a sound field under conditions where the listener was stationary and also when the listener was moving.

Design: Listeners sat in a sound-deadened room and reported their perceived localization of sound sources presented from a range of twelve loudspeakers in their frontal hemifield spaced 15 degrees apart, or six

loudspeakers concentrically surrounding the listener at 60 degrees apart. Stimuli were wideband noises of three second duration presented at several different levels. Under half of the conditions, listeners were asked to keep their head stationary; for the other half listeners were asked to rotate their heads back and forth over a +/-30 degree arc relative to the listeners' midline.

Results: Preliminary results suggest that synchronization of AGCs results in improved lateral localization under conditions when listeners are stationary.

Conclusions: Synchronization of AGCs offers one promising strategy for improving localization performance for bilaterally-implanted CI patients.

Poster # 121

Recall in Cochlear Implant Recipients: Impact of CVLT-3 Scoring Methods

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Objectives: 1.Determine how various scoring methods on the California Verbal Learning Test, Third Edition (CVLT-3) provide different cognitive profiles in adult cochlear implant (CI) recipients with post-lingual deafness.2.Assess relationships between the cognitive processes of immediate recall and hearing-in-noise ability. Hypotheses: 1.Varying scoring method will impact the resulting cognitive profile.2.Immediate recall ability will positively correlate with hearing-in-noise ability in adult CI recipients with post-lingual deafness.

Design: This within-subjects design included 15 experienced CI recipients, recruited from the patient pool at the Center for Hearing and Skull-Based Surgery at The Swedish Neuroscience Institute in Seattle, WA, USA. Various speech perception and cognitive criteria were employed for inclusion. Participants included unilateral and bilateral CI as well as bimodal recipients. All testing procedures were approved by the Swedish Medical Center Institutional Review Board.Participants were administered the Immediate Free Recall portion of the CVLT-3 which asked them to recall a list of 16 words. CVLT-3 test stimuli are administered using the auditory modality. Two different scoring methods were applied to the data to provide a comprehensive perspective of the cognitive mechanisms underscoring immediate recall. Primacy (first 4 words), pre-recency (middle 8 words) and recency (last 4 words) metrics were calculated in two ways to create serial position curves:1.CVLT-3 Manual Scoring Method: Calculating immediate recall scores for primacy, pre-recency and recency words recalled divided by the total number of words correctly recalled for all regions (i.e., 16 words) 2.Alternative Scoring Method: Calculating immediate recall scores for primacy, pre-recency and recency words divided by the total number of words in a respective region (i.e., 4, 8, and 4 words respectively)AzBio sentences in noise were recorded in the best-aided condition. Relationships between the varied CVLT-3 metrics and AzBio were quantified with correlations and repeated measures analysis of variance (ANOVA).

Results: Significant differences in cognitive profiles depending on the CVLT-3 scoring method used were observed in this sample. Performance comparability for primacy, pre-recency and recency regions to normative data varied for this sample, depending on scoring method used, with variability from trial to trial. While various trial/region-dependent scores revealed significant relationships with hearing-in-noise ability, averaging regional recall scores with the alternative scoring method across 5 trials most strongly related to best-aided hearing in noise ability in CI recipients.

Conclusions: Our work shows that distinct methodologies for the calculation of immediate recall ability yield different results. When employing standard CVLT-3 scoring methods, adult CI recipients demonstrate distinct recall patterns compared to normative data. When employing an alternative scoring method, this population demonstrates similar recall patterns compared to normative data. The relationship observed between immediate recall and hearing-in-noise abilities suggests that immediate recall ability warrants further exploration as a potential predictor for hearing-in-noise outcomes in CI recipients.

Poster # 122

Contralateral Ear Device Selection for Unilateral Cochlear Implant Recipients

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Objectives: The goal of the study is to identify clinical guidelines for assessing which device may be of more benefit, a hearing aid (HA) or CROS, to unilateral cochlear implant (CI) recipients who have limited bimodal benefit and are unwilling or unable to get a second CI. We hypothesize that a) patients with poor word understanding on the non-implant ear will have better speech comprehension in challenging listening situations while listening with Naida Link HA or the CROS device as compared to listening with the CI alone b) sound awareness (lateralization) will improve when participants are listening bimodally (CI+HA).

Design: Twenty adults with a unilateral Advanced Bionics CII or later implant and with at least 6 months of CI experience will be recruited. Subjects may or may not be clinically using an HA in the non-CI ear. Test measures include speech recognition scores (IEEE sentences as target, two-female talker as interferer, Snon-CINCI), lateralization (±60° speaker locations, 1 second duration pink noise) and custom questionnaires. Speech recognition and lateralization are assessed in a clinical soundbooth with a two speaker set-up. Custom questionnaires assess baseline hearing needs and perceived benefit with each listening configuration (CI only, CI+HA, CI+CROS).The study comprises of four visits. At visit 1, baseline screening and test measures with CI only are conducted. Subjects are then randomly fit with either an HA or a CROS and sent home for 4 weeks. At visit 2, test measures are obtained in the CI+CROS or CI+HA device configuration. The contra-ear devices are then switched and subjects are sent home with the 'new' device configuration. Participants return again after 4 weeks for visit 3 where test measures are obtained with that device configuration. Overall device preference is gathered.

Results: To date, 18 subjects have completed visit 1. Three additional subjects were screened but did not meet the criteria for the study. Seventeen subjects have completed visit 2. At visit 2, 7/17 subjects were tested in the CI+HA device configuration and 10 with CI+CROS device configuration. While the same subjects have not yet been tested with both HA and CROS, data so far show a 28.9% improvement in the CI+HA configuration and 24.7% in the CI+CROS configuration as compared to CI only. We anticipate presenting the entire data set with analyses and suggested guidelines at the meeting.

Conclusions: Cochlear implants have been largely successful for patients who have profound or severe hearing impairment. Patients can expect to have fairly good to excellent speech understanding in quiet. However, speech performance with background noise is still poor. Various accessories have been developed and approved to improve performance in these areas. The Naida Link HA and Naida Link CROS are two such devices developed to improve hearing outcomes for unilateral CI users. It is surmised that a two-ear solution (Naida link or CROS) will improve speech perception and sound awareness for unilateral CI users, particularly in background noise.

ELECTROPHYSIOLOGICAL RESPONSES

Poster # 123

Search for Electrophysiological Indices of Hidden Hearing Loss Using Sustained Brainstem Measures
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Objectives: Recent studies in animals suggest that even moderate levels of noise exposure can damage synaptic ribbons between the inner hair cells and auditory nerve fibers without affecting audiometric thresholds, giving rise to the use of the term "hidden hearing loss" (HHL). Given the pervasive exposure to occupational and recreational noise in the general population, it is likely that individuals afflicted with HHL will go unidentified unless sensitive clinical measures are developed to diagnose this condition. The objective of the project is to search for sensitive clinical electrophysiologic measures for early detection of HHL using sustained brainstem measures.

Design: In an effort to develop sensitive clinical electrophysiologic measures for early detection of HHL we evaluated the frequency following response elicited by (1) a steady-state vowel (English back vowel /u/) in quiet, and in the presence of speech shaped noise presented at 0 and +5 dB SNR; and (2) tonal sweeps presented at different sweep rates. Participants were young normal-hearing individuals who participated in the marching band for at least 5 years (high-risk group) and non-marching band group with low noise-exposure history (low-risk group).

Results: Preliminary findings of the study indicated no group differences in either the envelope or F1 encoding of the steady-state vowel stimulus in quiet and in the presence of noise. However, the neural representation of tonal sweeps was enhanced at faster rates for the high-risk group.

Conclusions: This pattern of results suggests the complex interaction of a multitude of factors including music experience, sound over-exposure, and homeostatic central compensation. A larger-scale dataset with different noise exposure background, longitudinal measurements with an array of behavioral and electrophysiological tests is needed to better understand the complex nature of sound over-exposure in normal-hearing individuals to develop a sensitive clinical measure.

Poster # 124

Inter-Aural Difference Norms for Wideband Acoustic Immittance (WAI): Potential for Identifying Otosclerosis
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Objectives: Purpose: Wideband acoustic immittance (WAI) is a field of noninvasive diagnostic measures that are used to evaluate the status of the middle ear. Wideband absorbance (WBA) is a WAI tool that distinguishes normally-hearing from pathological middle ears with a high level of diagnostic accuracy. This work aims to

further improve the diagnostic efficiency of WBA, by providing a set of normative data which represents the typical inter-aural difference of WBA in adults of Caucasian, Asian and Mixed ethnicities.

Design: Design: This retrospective analysis examined records of WBA obtained from normally-hearing adults (N=122; mean age= 24.16 yrs) using the Titan by Interacoustics immittance equipment. Norms were established for individual ear measures, and the inter-aural difference of WBA measured within-subjects. A mixed model ANOVA was used to analyze how normative WBA measures are affected by factors of ethnicity, gender, and test pressurization method. A comparison of the diagnostic efficacy of the two WBA measurements was conducted with an ROC analysis, using WBA records from 28 subjects with surgically confirmed otosclerosis as a clinical group.

Results: Results: The ROC analysis confirmed that diagnostic accuracy of WBA individual ear and inter-aural difference measures was equal for the detection of otosclerosis; however, these measurements may provide complementary information regarding middle ear status. WBA norms based on individual ear data varied significantly depending on ethnicity, gender, and test pressurization method across frequencies. WBA norms based on inter-aural difference values only varied significantly with test pressurization method across frequencies, though the difference was small and likely does not have any clinical relevance, at least for the detection of otosclerosis.

Conclusions: Conclusion: WBA norms based on inter-aural difference values did not depend on population-based factors of ethnicity or gender; the same set of normative data may be used reliably across these populations. Parameterization of norms for individual ear WBA data is recommended based on ethnicity, gender and test pressurization method. Inter-aural difference norms for WBA may be instrumental in interpreting immittance results for individuals with unilateral conductive pathology, or for populations for which other forms of normative data are not available.

Poster # 125

VEMP Responses at 500 and 750 Hz in Adult Patients

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Objectives: Vestibular-evoked myogenic potentials (VEMPs) are recorded with stimulation of the otolith organs. Cervical VEMPs assess the integrity of the saccule and the inferior vestibular nerve. Ocular VEMPs assess the integrity of the utricle and the superior vestibular nerve. A 500 Hz tone-burst at 95 dB nHL is the most commonly used stimulus in clinical settings. Data supports best responses are evoked from young normal adults at this frequency. However, there is evidence older normal adults have a lower response rate for this stimulus. Response rates in older subjects are better for 750 Hz tone-bursts compared to 500 Hz. The purpose of this study was to compare VEMP performance with 500 and 750 Hz tone burst stimuli in a patient population.

Design: Subjects were recruited from patients referred for evaluation. The young group included 8 subjects (mean age = 38.3). The older group included 8 subjects (mean age = 77.3). No subject had conductive hearing loss. cVEMPs and oVEMPs were recorded using 500 and 750 Hz tone bursts. Counterbalancing was used to reduce order effects. Standard electrode derivations were used.

Results: The older group had longer p13 latencies ($p=0.002$) and smaller cVEMP amplitude ($p<0.001$) compared to the young group. When cVEMP response rates were considered, 93.75% of the young group had a

response for 500 Hz, compared to 68.75% of the older group. Rates were lower for both groups using 750 Hz at 75% for the young group and 43.75% for the older group. Although there was no effect of stimulus frequency on latency or amplitude for the subjects who had cVEMPs, there is an effect on response rate for both age and tone burst frequency. The older group had longer n10 latencies ($p=0.001$) and smaller oVEMP amplitudes ($p<0.001$). When oVEMP response rates were considered, 81.3% of the young group had a response for 500 Hz, compared to 50% of the older group. Response rates were lower for both groups using 750 Hz at 68.8% for the young group and 31.3% for the older group. Older subjects were less likely to have oVEMPs regardless of stimulus frequency and both groups had lower response rates for 750 Hz compared to 500 Hz.

Conclusions: Results indicate increased initial wave latencies and smaller response amplitude in older subjects compared to young subjects for both cVEMP and oVEMP. These results agree with the literature for normal subjects. We saw no effect of tone burst frequency (500 Hz and 750 Hz) on these parameters which is in agreement with the literature for normal subjects. Older subjects had lower cVEMP and oVEMP response rates than young subjects. This is in agreement with the literature for normal subjects but our overall response rates were lower. Our results vary from reports on tone burst frequency and response rate. The literature indicates more normal subjects have VEMP responses at 750 Hz compared to 500 Hz. In both of our age groups, lower response rates were recorded for 750 Hz compared to 500 Hz. 750 Hz may be more sensitive to otolith organ impairment.

Poster # 126

Detection of Cochlear Synaptopathy using EFRs: Influence of Stimulus Envelope

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Objectives: Permanent threshold elevation after noise exposure or aging is caused by loss of sensory cells; however, animal studies show that hair cell loss is often preceded by degeneration of synapses between sensory cells and auditory nerve fibers. The silencing of these neurons is likely to degrade auditory processing and may contribute to difficulties understanding speech in noise. Reduction of suprathreshold ABRs can be used to quantify neuropathy in inbred mice. However, ABR amplitudes are highly variable in humans, and thus more challenging to use. Since noise-induced neuropathy is selective for fibers with high thresholds and low-spontaneous rate, and because phase locking to temporal envelopes is particularly strong in these fibers, measuring envelope following responses (EFRs) might be a more robust measure of cochlear synaptopathy. A recent computational model (Verhulst et al., 2018), suggests that stimuli with squared modulation envelopes should be more sensitive to cochlear synaptopathy than sinusoidally amplitude modulated (SAM) tones of equal intensity. Here, we test whether EFR amplitudes to squared vs. sinusoidal modulation were better correlated with word scores among listeners with normal audiograms.

Design: 124 native speakers of English between the ages of 18 and 63 were enrolled in this study. All participants had normal thresholds at standard audiometric frequencies, normal middle-ear function and passed

the MoCA test for mild cognitive dysfunction. DPOAEs were measured at standard or extended high frequencies. Word-recognition performance was assessed using 1) NU-6 word lists of 50 CNC phonemically balanced words at 55 dB HL presented with or without an ipsilateral speech-shaped noise masker at 0 dB SNR or speeded up at 45% or 65% with added reverberation and 2) a modified version of the QuickSIN consisting of lists of sentences in the presence of a four-talker babble noise at decreasing SNRs. EFRs were obtained in response to sinusoidally AM tones (1 or 8 kHz) delivered at 85 dB SPL with a modulation frequency of 128 Hz or 750 Hz (100% modulation depth). Additional EFRs were measured in a subset of 60 participants in response to a 4-kHz tone modulated by a square-wave at 120 Hz delivered at 70 dB SPL.

Results: EFR magnitudes evoked by a squared-envelope stimulus were significantly correlated with all word scores, whereas those evoked by sinusoidally modulated tones were not, consistent with a recent computational model of the human auditory periphery suggesting that square-wave modulation, unlike sinusoidal modulation, drives the auditory nerve with little influence of outer hair cell deficits. In addition, measures of hair cell function as assessed behaviorally or via DPOAEs at standard audiometric frequencies and extended high frequencies were not correlated with speech scores, consistent with selective neural loss.

Conclusions: These results, showing that word-recognition scores correlate with the square-wave (but not SAM) EFR magnitude suggest that individual differences in synaptopathy may be a source of speech recognition variability. These results further support the idea that cochlear synaptopathy leads to deficits in hearing-in-noise, despite the presence of normal thresholds at standard audiometric frequencies.

Poster # 127

Acoustically Evoked Compound Action Potentials (CAPs) Recorded from Cochlear Implant Users with Preserved Acoustic Hearing

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Objectives: Less traumatic electrode design and the introduction of 'soft surgery' techniques allow for preservation of low-frequency acoustic hearing in many cochlear implant users. For these cochlear implant users, noninvasive recording method was developed that allow acoustically-evoked peripheral responses to be measured in vivo from an intracochlear electrode. Unfortunately, responses generated from the auditory nerve (auditory nerve neurophonic) are smaller than hair cell responses (cochlear microphonic) and complete segregation of the auditory nerve neurophonic from the cochlear microphonic has proven difficult, complicating interpretation and limiting clinical applications. The status of the auditory nerve can also be assessed using compound action potentials (CAPs). CAPs are the synchronous response of multiple auditory nerve fibers. Importantly, CAPs should not be subject to contamination by hair cell responses. However, recording CAPs from cochlear implant users has been challenging using standard clicks and tone bursts; CAPs are measurable from only ~ 50% of subjects with highly variable response morphology. We suggest using chirps, presuming that enhanced cross-fiber neural synchrony offered by chirps would lead to better CAP responses. This study describes within-subject comparison of CAPs recorded using traditional stimuli (clicks, tone bursts) and new stimuli (chirps). We hypothesize that chirps will enhance CAP amplitudes and waveform morphology compared to traditional stimuli, improving the accuracy of assessing the status of the auditory nerve in cochlear implant users with residual acoustic hearing.

Design: Ten adult Cochlear Nucleus L24 Hybrid CI users participated. All had post-operative audiometric thresholds better than 80dBHL at 125 - 500Hz and used an acoustic component regularly in the implanted ear. CAP amplitude growth functions were recorded from the most apical intracochlear electrode using standard clicks, 500 Hz tone bursts, and chirps presented via an insert phone to the implanted ear. The chirp stimulus using parameters based on human derived-band CAP data ('CAP chirp') was used. Nine chirps with systemically varied frequency sweep rates were also generated by modifying parameters in the chirp equation to determine an optimal chirp. CAPs will be compared based on peak amplitude, latency, threshold, and response morphology across stimuli.

Results: Chirp-evoked CAPs were more consistent and reliably measurable than click-evoked CAPs at suprathreshold levels. However, chirp-evoked CAPs had slightly elevated thresholds than click-evoked CAPs. Tone burst-evoked CAPs were less frequently recorded. Results also provided an evidence that variations in the frequency sweep rates used to generate chirps impact CAP waveform morphology. For some subjects, larger CAP amplitudes and sharper peak morphology were obtained when chirps with a faster rate of frequency change was used, particularly for those subjects with poorer high-frequency hearing.

Conclusions: Results suggest that CAPs can be measured effectively using chirps from an intracochlear electrode. Chirps may present an attractive alternative to standard clicks and low-frequency tone bursts in cochlear implant users with residual acoustic hearing. The advantage of using chirps may also prove to be dependent on the frequency sweep rate used to generate chirps and potentially also audiometric configuration. This implies further clinical application of customizing chirps on an individual basis according to the audiometric configuration in this cochlear implant population.

Poster # 128

Perceptual and Electrophysiological Correlates of Fixed vs. Moving Auditory Targets
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Objectives: Cortical mechanisms involved in the perception of fixed vs. moving targets have been studied with various brain imaging methods, but there is a dearth of research tying perceptual findings to those of electrophysiology. In the present study, we asked, "How do obligatory cortical auditory evoked potentials (CAEPs) reflect perception of fixed vs. moving sound sources?" To answer this question, we evaluated CAEP and perceptual metrics of sound lateralization for fixed vs. moving targets, varying interaural time differences (ILD) and interaural time differences (ITD).

Design: 20 normal-hearing young adults participated. Stimuli were pulse trains in which the first 1000 ms were diotic, and the next 655 ms were dichotic, reflecting either a discrete ('fixed') change in ITD and/or ILD, or a dynamic ('moving') change in ITD and/or ILD. ITD and ILD cue magnitudes were systematically manipulated in both leftward and rightward directions. Perceptual laterality ratings and CAEPs were obtained for 25 unique stimulus conditions.

Results: The stimulus variables of fixed vs. moving spatial change, binaural cue magnitude, and type of binaural cue (ITD, ILD or combined ITD/ILD) had significant effects on laterality judgement, but direction of change (right vs. left) did not. Laterality ratings were reduced for moving compared to fixed targets, for single ITD or ILD cues vs. combined cues, and for the smaller ITD and ILD magnitudes. Steeper lateralization growth functions were obtained for fixed targets compared to moving targets as a function on binaural cue magnitude. Furthermore, when ILD was the only cue available, moving targets were lateralized exceptionally weakly

compared to all other stimulus combinations. Fixed-type spatial changes evoked a robust CAEP - 'Spatial Change Onset Response' (SCOR), whereas moving-type spatial changes did not. In contrast to what was observed perceptually with lateralization judgements, there was no appreciable growth in SCOR amplitudes when ILD and ITD cues were concomitantly available to the listener, compared to when the cues were presented in isolation. Hemispheric differences were evident in the SCOR-N1, with larger amplitude over the hemisphere contralateral to lateralized stimuli, regardless of the binaural cue available to the listener. Although moving targets did not evoke SCORs, their stimulus offset CAEPs exhibited greater negativity compared to fixed targets. Moreover, moving targets evoked greater right hemisphere activity relative to fixed targets. SCOR amplitudes for fixed targets exhibited a clear relationship with perceptual ratings of laterality, with R2= 0.85. At the single-subject level, subjective-objective growth functions (i.e., SCOR amplitudes plotted by lateralization ratings) were robust.

Conclusions: Fixed changes in ITD and ILD evoke CAEPs that are congruent with perceptual ratings of laterality. This finding suggests that cortical electrophysiology could be used as a clinical metric for lateralization, and underlying disorders of central auditory processing of interaural time and level differences. Although moving tokens constituting ecologically-valid velocities did not evoke robust SCORs, their offset responses suggest differences in cortical mechanisms underlying spatial listening for fixed vs. moving stimuli. Next steps will be to extend the research to groups with known deficits in central auditory processing for binaural cues, such as those with traumatic brain injury.

Poster # 129

Wave I Tendency of Auditory Brainstem Response in Cochlear Synaptopathy

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Objectives: In general, patients who suffer from noise-induced cochlear synaptopathy report a difficulty in understanding speech under background noise, but they have apparently normal hearing sensitivity. Thus, the clinicians have worked for their accurate diagnosis in terms of audiological outcomes. Although different results of the previous studies, the cochlear synaptopathy is reported as characteristics with a reduced amplitude and delayed latency in Wave I of the auditory brainstem response (ABR). In the present study, we aimed to scrutinize a specific tendency of ABR Wave I for the cochlear synaptopathy using a systematic review and meta-analysis.

Design: Combination key terms of 'cochlear synaptopahty', 'auditory brainstem response', 'ribbon synapses' were searched by seven electronic databases (e.g., CINAHL, Embase, Medline complete, Pubmed central, Scopus, Science Direct, Web of science). After screening and reviewing abstract of 1,036 articles, 31 articles with full text were considered as an eligible condition. According to our inclusion criteria, a total of 15 studies were qualified for the systematic review and meta-analysis. The effect size of data was calculated by a random effect model with mean differences and 95% confidence interval. Heterogeneity among the studies was evaluated by using Q-test and I2-statistics. Also, the publication bias was identified by using funnel plot and Egger's regression test. If results of the meta-analysis showed a high heterogeneity, the sub-group analysis was performed by three key factors of ABR (e.g., stimulus, rate, intensity).

Results: Fifteen reviewed articles summarized that the most commonly measuring condition was click or 4 kHz tone burst stimulus at a rate of less than 11/sec at more than 80 dB intensity levels with alternating polarity when using insert earphone or tip-trode at the ear canal. In the click ABR, latency was revealed in between 1.6 and 1.8 ms regardless of different intensity levels for the cochlear synaptopathy group, which was a slightly delayed in latency than normal hearing counterparts. The meta-analysis resulted that mean of Wave I amplitude had lower effect size (-0.0509, 95% CI: -0.0934 ~ -0.0085) in the cochlear synaptopathy group, compared to the control group. With a high heterogeneity (I2 = 94.2%), funnel plot showed some publication bias (p = 0.5983). The results of Egger's regression also indicated publication bias in stimulus (I2 = 92.09%), rate (I2 = 93.43%), and intensity (I2 = 95.01%). However, combined Egger's regression tests of stimulus, rate, and intensity showed lower heterogeneity (I2 = 44.79%), whiling supporting a significant difference between variables in stimulus ($p < 0.0001$) and rate ($p < 0.0033$).

Conclusions: Although still including the heterogeneous testing conditions and a small number of studies, it is clinically differentiated to measure ABR Wave I using a click or 4 kHz tone-burst stimulus of the rate of less than 11/sec at 80 dB or higher intensity levels with alternating polarity, when suspected to be a patient with noise-induced cochlear synaptopathy. However, we suggest that those ABR conditions should be applied to a large number of patients and thus standardized as their sensitive features in the further study.

Poster # 130

Investigating Neural Factors Underlying Medial Olivocochlear Reflex Strength

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Objectives: The medial olivocochlear reflex (MOCR) is thought to protect the inner ear from acoustic trauma. Findings in lower mammals have led to the hypothesis that humans with a weak MOCR are most susceptible to noise-induced hearing loss. MOCR strength is approximately normally-distributed across normal-hearing ears. However, factors underlying this distribution, specifically those yielding especially strong or weak reflexes are poorly understood. Knowledge of such factors may facilitate development of training methods to strengthen weak reflexes. The current work investigated the role of spectral integration of afferent activity by the MOC neurons on MOCR strength. We hypothesized that individuals with a weak MOCR exhibit reduced spectral integration.

Design: Participants included 17, normal-hearing young adults. The MOCR assay involved measurement of click-evoked otoacoustic emissions (CEOAEs) in the ipsilateral ear concurrent with contralateral noise and quiet. The MOCR was activated using five band-limited noise stimuli. Bandwidths were centered around 2 kHz and ranged from ±0.5- to ±2.5-octaves (1-octave steps). Spectral levels (dB/Hz) were held constant across the noise bandwidths. For each activator, MOCR strength was calculated as the percent change in the 2-kHz CEOAE (magnitude + phase) between contralateral-noise and quiet conditions. Resampling-without-replacement was performed to identify statistically significant MOCR effects for each subject and MOCR activator. The dependence of MOCR strength on activator bandwidth was evaluated using non-linear mixed-effects modeling employing a 1st-order power function. A random-effect of subject was included for both the scaling factor and slope parameters of the power function. The slope parameter provided a metric of spectral integration with steeper slopes indicating greater spectral integration.

Results: MOCR strength increased with the bandwidth of the MOCR activator and was well approximated by a 1st-order power function. On average, MOCR strength increased from 10% to 30% as the noise bandwidth increased from 1- to 5-octaves. A significant random-effect of subject was identified for the scaling factor but

not the slope parameter of the power function. Wideband MOCR strength (based on the 5-octave wide MOCR activator) was positively correlated the subject's scaling factor parameter.

Conclusions: For all subjects, MOCR strength increased with the bandwidth of the activator. However, findings suggest that inter-subject variability in spectral integration is not a significant contributor to inter-subject differences in wideband MOCR strength. Rather, individuals with a weak MOCR in response to wideband noise also possess a weak MOCR in response to narrow-band noise.

Poster # 131

Statistical Detection of cVEMPs: Effect of Stimulus Level

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Objectives: The cervical vestibular evoked myogenic potential (cVEMP) is considered an objective measure of saccular function. Like auditory evoked potentials (AEPs), cVEMP detection is highly subjective when the response has a small signal-to-noise ratio (SNR). This is problematic because in recordings with a small SNR (e.g., cVEMP threshold or small amplitudes), response detection is performed visually and is primarily dependent upon the experience of the examiner. Statistical detection methods such as fixed single point (Fsp) have been shown to objectively detect AEPs for decades but have been rarely applied to cVEMPs. Previous investigators applying Fsp to VEMPs have found promising results; however, several questions remain unanswered. Specifically, previous studies have not examined Fsp behavior across stimulus level - especially in recordings with small SNRs. The purpose of this study was to apply a statistical detection method (i.e., Fsp) to cVEMPs and evaluate whether Fsp is sensitive to changes in stimulus level.Hypotheses:1.As stimulus level decreases, Fsp values will also decrease. 2.Response threshold detected by Fsp will be lower than the threshold defined by visual detection. 3.There will be no significant difference in the Fsp values calculated when the noise estimate is obtained from different latency points (e.g., -8 ms, -4 ms, etc.).

Design: Twenty young adults (ages 18-22) participated in the study and denied any history of hearing or balance disorders. Stimuli consisted of a transient tone burst at 500 Hz delivered by a clinical bone oscillator, the B71 by Radioear. A visual bar graph was used to monitor electromyography (EMG) activation in real time throughout the recordings. MATLAB was used to calculate Fsp from bone conduction (BC) cVEMP data that were collected previously. The Fsp algorithm was applied to the dataset starting with the highest stimulus level (i.e., 55 dB nHL); Fsp analysis was then performed in 5 dB steps down to 5 dB below the visually detected cVEMP threshold.

Results: Preliminary results suggest that average Fsp ratios were comparable across stimulus levels. Additionally, Fsp appears to detect lower cVEMP thresholds than visual detection, consistent with the current literature. Finally, there does not appear to be a significant difference between Fsp ratios calculated from different latency points (e.g., -8 ms, -4 ms, etc.).

Conclusions: The purpose of this study was to examine if Fsp, when applied to BC cVEMPs, was sensitive to changes in stimulus level. Preliminary findings suggest that Fsp does not decrease as expected when stimulus level decreases from 55 dB nHL to 35 dB nHL. Additionally, present responses were detected by Fsp below the visually detected threshold, as expected. It is currently unclear how the noise estimate (i.e., EMG activation) during the recording affects Fsp. Future studies should investigate the underlying background noise and its

effects on Fsp. Understanding statistical detection in cVEMP recordings could serve as a promising objective measure of vestibular screening and improve clinical protocols.

Poster # 132

Test-Retest Reliability of Click-Evoked Auditory Efferents

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Objectives: The auditory efferent system, specifically the MOCR, plays an important role in hearing as it regulates cochlear gain. It is thought to unmask signals from noise and protect cochlear hair cells and neural synapses from loud noises. Testing the strength of the efferent system has potential clinical implications in predicting vulnerability to noise-related damage and in auditory disorders such as hyperacusis and auditory neuropathy spectrum disorders. Conventionally, MOCR activity is inferred by monitoring change in OAEs while eliciting the reflex using noise in the contralateral ear. While this technique provides an estimate of the MOCR strength, it is typically only the contralateral pathway, and no information about the temporal aspects of the reflex can be gleaned. Prior studies also report subpar within- and across-session repeatability for this "conventional" method. The current study aims to investigate the test-retest reliability of a novel test of the efferent system, and compare it to the reliability of the conventional paradigm. The proposed click-evoked MOCR test allows for simultaneous, bilateral monitoring of the MOCR over time and measures the reflex time-constants. Given that the MOCR magnitude is extracted from multiple data points using statistical line-fits in the novel method, we hypothesize that the novel testing paradigm will exhibit better test-retest reliability when compared to the conventional paradigm.

Design: Data will be collected from 20 adult participants with normal hearing across two sessions, as close to four weeks apart as feasible. We will measure the click-evoked MOCR for clicks presented bilaterally with a rate of 62.5 Hz and at levels from 80-95 dB (peak-to-peak) ppSPL. Clicks (0.8 - 4.8 kHz) will be calibrated in each ear individually with forward pressure level (FPL) to ensure a flat spectrum at the eardrum. The measures of click-evoked MOCR will be repeated across two sessions and twice within the second session to assess the within- and across-session variability. Test-retest reliability of the MOCR will also be assessed following a conventional paradigm, in which clicks will be presented in one ear (60 dB ppSPL; 40 Hz) and an intermittent broadband noise will be presented in the contralateral ear. The test ear for the conventional MOCR test will be randomly chosen and counterbalanced across participants.

Results: Data have been collected from 9 participants for the first session. A repeated measures analysis of variance (ANOVA) will be used to determine if the MOCR metrics, elicited by noise and clicks, differ within and across sessions. Intra-class correlation coefficients will be calculated for the novel and conventional tests of the MOCR. Bland-Altman plots will be visualized and limits of agreement will be calculated for the two methods. The test-retest metrics will also allow us to develop a normative range of the MOCR function by establishing the "smallest real difference".

Conclusions: Pending completion of data collection, the results will contribute to the clinical translation of our method. Comparison with the conventional method will allow for further refinements. The development of normative data based on the test-retest metrics will augment our test and facilitate clinical uptake.

Poster # 133

Age-Related Degradation of Amplitude-Modulated Cervical Vestibular Evoked Myogenic Potentials (AMcVEMPs)

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Objectives: Cervical vestibular evoked myogenic potentials (cVEMPs) have been used extensively to assess saccular function, and age-related degradations have been previously reported using transient cVEMPs elicited by brief tonebursts. The present study uses an innovative approach including amplitude-modulated (AM) tones to elicit cVEMPs (AMcVEMPs). This steady-state approach to AMcVEMPs allows a variety of analyses to be applied to these data, such as signal-to-noise ratio (SNR) and phase coherence. Effects of aging may be better understood if assessed using a wider variety of methodologies. In addition, AMcVEMP thresholds may reflect age-related changes in the sensitivity of the otolith organs. Auditory steady-state response thresholds vary with which detection algorithm is applied, but it is currently unknown whether different detection algorithms yield different AMcVEMP thresholds.The purposes of the present study were 1) to characterize the effect of age on AMcVEMPs, and 2) to compare AMcVEMP thresholds determined by several objective detection algorithms.The hypotheses of the present study were that 1) AMcVEMP amplitude, SNR, phase coherence, and magnitude squared coherence will become poorer with increasing age, and 2) AMcVEMP thresholds determined by SNR and phase coherence will be poorer than those determined by magnitude squared coherence.

Design: Groups of young (n = 17, mean age = 27), middle-aged (n = 13, mean age =49), and older (n = 12, mean age = 67) adults with no history of vestibular lesions or middle-ear pathologies participated in this study. Stimuli were amplitude-modulated tones with a carrier frequency of 500 Hz and modulation frequency of 37 Hz. Stimuli were presented from 65 to 40 dB HL using a B81 bone oscillator. Subjects monitored electromyographic activation in real time to maintain muscle activation at 50 ¬µV. AMcVEMP analyses were FFT-based and included four analyses: amplitude, SNR, phase coherence, and magnitude squared coherence. AMcVEMP thresholds were defined using detection algorithms of SNR, phase coherence, and magnitude squared coherence.

Results: Middle-aged and older adults had significantly smaller (poorer) amplitudes than younger adults. SNR, phase coherence, and magnitude squared coherence showed similar age-related degradations. These age differences were observed at all stimulus levels tested. AMcVEMP thresholds were significantly higher (poorer) for older adults. Average AMcVEMP thresholds were 51.4 (stderr = 2.2), 56.7 (stderr = 2.0), and 64.8 dB HL (stderr = 2.1) for the younger, middle-aged, and older groups, respectively. However, AMcVEMP thresholds were not significantly different between the different detection algorithms.

Conclusions: Age-related degradations were observed in all AMcVEMP analyses. In addition, AMcVEMP thresholds were higher (poorer) in middle-aged and older adults relative to younger adults. Results from this study will enhance the understanding of how aging affects the vestibular system and may inform approaches to clinical vestibular assessment.

HEARING LOSS / REHABILITATION

Poster # 134

Efficacy of Music Training for Individuals with Hearing Loss

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Objectives: Currently, music training has been used as one of approaches in aural rehabilitation for those who have hearing impairment. Although handful of research has been made to investigate some improvements in their music training, there is still a lack of systematic outcomes on the efficacy of music training to the individuals with hearing loss that been fitted with hearing aid (HA) or cochlear implant (CI) in terms of age, device type, and previous music experience. In the present study, we aimed to scrutinize the efficacy of music training for many HA and CI users on improvement of musical perception by using a technique of systematic review and meta-analysis.

Design: First of all, 9,422 articles were searched from five electronic databases (i.e., ScienceDirect, Scopus, PUBMED, CINAHL, Web of Knowledge) by using a combination of keywords in 'music training', 'music perception', 'auditory perception', 'speech perception', 'training time', and 'training content'. In the screening process, 43 full text articles were considered as eligible. Studies investigating music training effect on individuals with hearing loss and outcome measurements related to speech or music perceptions were included. According to our inclusion criteria, a total of 10 studies were qualified for the systematic review and meta-analysis. The data from 10 articles were extracted and meta-analysis was run by using Comprehensive Meta-Analysis software. The effect size of data was calculated and evaluated by using Q-test and squared I-statistics. Funnel plot and Egger's regression were performed to identify any publication bias. If finding a high heterogeneity, subgroup analysis was also run by using three key factors: age group (adults vs. children), hearing device used (CI vs. CI and HA), and participant previous exposure to music training.

Results: A total of 10 studies with 165 participants were analyzed. Overall, the music training resulted in significant improvement of their perceptual ability when comparing pre- and post-trainings. The meta-analysis showed standard difference in means of musical improvement as effect size of pre-post training [1.42, 95% CI: 1.16 to 1.64]. Although heterogeneity of studies was high (I^2= 83.79) and funnel plot provided asymmetrical graph, Egger’s regression showed no significant publication bias (p=0.131). Meta-ANOVA test on subgroup was analyzed as the further step. Results of the subgroup yielded high heterogeneity in age group (I^2= 76.51) and type of hearing device used (I^2= 77.771), and also high heterogeneity in their musical experience (I^2=83.41). In detail, there was significant difference of musical improvement between adults and children groups (p=0.044). In the device type, the group only listening with CI and the group who listening as bimodal mode by CI and HA showed significant difference in music perception performance (p=0.003). However, there is no significant difference of improvement on whether the participants previously have musical experience or not (p=0.48).

Conclusions: The present study confirm that music training does improve music perception of individuals with hearing loss and effective approach for aural rehabilitation, while suggesting that amount of training effects are different depending on age and the mode of hearing in the trainees.

Poster # 135

A Hearing Health Care Needs Assessment in Rural Alabama

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Objectives: This study identified the perceived needs of those living with hearing loss in rural areas of Alabama.

Design: This study used a Community-Based Participatory Research (CBPR) design to assess the needs of adults with hearing loss who live in audiological underserved areas of West Central and South Alabama. Fifteen adults with hearing loss and 11 medical or other community workers were recruited for the study. Adults with hearing loss were recruited from our database of approximately 80 adults with hearing loss who live in these communities. Medical and other community stakeholders were recruited from our associations that we have developed in these regions over the past four years. Adults with hearing loss were asked five questions during the discussions, including 1) What difficulties have you experienced in your daily life as someone who has hearing loss?; 2) Have you tried to get help for your hearing loss?; 3) If so, have you experienced some difficulties trying to get help and what are they?; 4) If you have not tried to get help for your hearing loss, are there specific reasons for this?; and 5) What do you think could be done to help you deal with your hearing loss in your daily life and in your community? Medical and other community stakeholders were asked two questions, including 1) What difficulties have you experienced working with or interacting with someone with hearing loss?; and 2) In your opinion, what are some steps that might help people with hearing loss living in your community? Participants were seen in groups of 2, 3 to 4, or individually, depending on schedules or individual requests. The conversations were manually and audio-recorded in real-time. Transcribed audio-recordings were analyzed for recurring themes by three study members. NVivo software was used to help organize the themes. The outcomes of the analysis were applied to the Socio-Ecological Model (SEM) of Health Behaviors.

Results: The primary themes that emerged from discussions with people with hearing loss focused on difficulty understanding in social settings, the financial burden associated with hearing loss, social or emotional issues, and the expressed need for increased resources in communities. For medical workers and other community stakeholders their needs were associated with how to relay important information, medical or otherwise, to people with hearing loss, and the need for increased services in their communities. Both groups of participants overwhelmingly expressed the need for more education or awareness of hearing loss to try to reduce misinformation. When applied to the SEM, the findings suggest that individual and community changes are needed in an effort to improve current practice and policies associated with hearing healthcare in rural communities.

Conclusions: Adults with hearing loss living in rural underserved communities experience communication difficulties but have no or limited resources to address a hearing loss, unlike their counterparts who live in areas with available resources. Our findings imply that policy changes in the service delivery model of hearing healthcare are needed to address these disparities.

Poster # 136

Effects of Criterion Selection on Consumer Ear Disease Surveillance Results

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Objectives: To evaluate the variation in consumer ear disease surveillance efficacy due to differences in criteria used to determine ear disease risk. We hypothesized that referral-driven and etiology-centered criteria would result in differences in ear disease risk estimation.

Design: Over 600 individuals were enrolled at four test sites in a prospective blinded evaluation of the Consumer Ear Disease Risk Assessment (CEDRA) questionnaire using otolaryngologist (ENT) opinion to determine the risk of ear disease. All participants were seeking hearing healthcare, completed the CEDRA questionnaire, and were then evaluated by an ENT physician. The ENT physician provided a medical opinion about the risk of ear disease by answering questions about clearance for hearing aid use, probability of age- or noise-related hearing loss, the need for further diagnostic testing, and associated symptoms and conditions. CEDRA test performance was estimated independently for each criteria and for a combined metric using receiver operating characteristics and standard measures of a confusion matrix.

Results: For the majority of participants, ENT-opinion about the risk for ear disease was consistent across the three criteria. CEDRA test performance was comparable to existing methods of disease risk screening, such as the FDA or AAO red flags. When hearing thresholds were combined with CEDRA results, test performance of the resultant hybrid test was superior to that of the existing red flag methods.

Conclusions: CEDRA is a viable consumer tool for ear disease risk assessment that can be utilized in over-the-counter and other hearing healthcare environments. CEDRA test performance is acceptable, exceeding that of current screening tools regardless of the criterion used. CEDRA has the advantage of not requiring the participation of a provider and varies little using three different criteria for ear disease risk. When hearing threshold tests were added to CEDRA, its performance exceeded that of existing red flag tests that require a medical provider. This hybrid CEDRA improves the ability to detect ear disease risk over current risk evaluation methods.

Poster # 137

Survey of Current Treatments for Normal-Hearing Patients with Communication Difficulties

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Objectives: It is not uncommon for audiologists to see patients who report significant communication issues but who present with normal or near normal pure-tone hearing thresholds. However, there are currently no evidence-based clinical protocols for treating patients with normal peripheral hearing sensitivity. Despite this lack of guidance, clinical audiologists are beginning to offer various auditory rehabilitation options for this unique clinical population. This work involved the creation of a survey for audiologists to explore treatment options that clinicians are currently offering to patients with normal hearing sensitivity and to determine whether these rehabilitation approaches have been successful for adult patients.

Design: The survey was disseminated via audiology-related email listservs and through information on business cards that were left at audiology conferences. Data collection occurred for four months beginning in March, 2019. Questions were separated into several sections: an introduction section that asked participants about their work setting and typical patient population, a section about details regarding hearing aid fittings in this population, a section about details regarding auditory training procedures for this population, and a section about patient follow up. Audiologists completed the survey online and participation was completely anonymous and confidential. A total of 208 audiologists responded from across various work settings.

Results: Survey data confirmed that a considerable number of adults seek out hearing health care for communication difficulties despite having normal peripheral hearing sensitivity and that a high proportion of these patients are generally interested in auditory treatment options. Participants reported that they most frequently perform counseling on effective communication strategies for these individuals, but many individuals across various work settings are also starting to successfully fit low-gain hearing aids on this patient population.

Conclusions: Results from this survey provided information regarding auditory rehabilitation methods that audiologists are currently using for individuals with normal hearing sensitivity who report difficulties communicating and provided information regarding the success of various treatment options. Response summaries that detail specific procedures for fitting low-gain hearing aids or suggesting auditory training options may be useful for clinical audiologists who are considering offering these rehabilitation approaches or who are already providing these treatment options to normal-hearing patients. In addition, this information will be used to guide the development of a focused, robust, large randomized control trial to better assess the effects of different treatment options on individuals with normal hearing and communication issues as well as provide more comprehensive clinical guidelines for the identification of patients that may be good candidates for a particular type of auditory rehabilitation approach.

Poster # 138

App-based Live Phone Call Transcription for the Hearing Impaired
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Objectives: The objective of this investigation was to assess if live transcription of smartphone calls provides measurable improvement in subjective and objective speech understanding.

Design: A pilot study was conducted of eleven participants with moderate-to-profound sensorineural hearing loss. All participants were experienced hearing aid users recruited from the Phonak Audiology Research Center participant database. Each participant was given the "myCall-to-Text" live transcription app that was developed by Phonak for a two week home trial. After the trial, objective speech understanding was measured with and without the app using recorded speech stimuli. Questionnaires were administered at the beginning and end of the study to measure changes in subjective speech understanding. A follow-up study is currently in process that is using the same study design. This follow-up study uses the same study design, but eligible participant criteria was restricted to those with severe-to-profound hearing loss or word recognition scores below 60% in each ear.

Results: The pilot study revealed improvements in subjective measurements of clarity of speech, speech understanding, ease of understanding, comfort understanding, and confidence. Objective measurements of

speech understanding revealed an improvement in performance across all participants. To understand this finding further, participants were separated into the two hearing loss groups, and this analysis showed that greatest improvement or benefit with the app was seen in the severe-to-profound-hearing loss group. Statistical analysis was not done on these subgroups due to the small sample sizes, but this result indicates the need for further investigation in the severe-to-profound population. Thus, a second study is being conducted to substantiate these findings with statistical evidence. Results from the second study are expected to be available in January 2020.

Conclusions: The pilot study of a live transcription smartphone app showed improvements on both subjective and objective measures of speech understanding with the app compared to without, providing initial evidence of the benefit this type of app can provide to individuals with hearing impairment, particular with severe-to-profound hearing impaired listeners.

Poster # 139

Improving the Hearing Aid Speech Perception Index (HASPI)

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Objectives: The Hearing Aid Speech Perception Index (HASPI) is a speech intelligibility metric intended for both normal-hearing and hearing-impaired listeners. The metric processes sentences through a model of the auditory periphery and then extracts envelope modulation and temporal fine structure (TFS) features that characterize the changes in the signal introduced by noise and nonlinear distortion. The objective of the work reported here is to improve the accuracy of HASPI for several different speech intelligibility datasets, including a new dataset providing monaural intelligibility scores for speech in reverberation.

Design: Two modifications are investigated to improve the accuracy of HASPI when applied to several existing datasets. The first modification is extending the range of envelope modulation rates considered in the metric. HASPI applies a lowpass filter to the time-frequency envelope modulation, and in the new version that single filter is replaced by a modulation filterbank. The TFS analysis in the original version of HASPI is replaced by the filterbank outputs at higher modulation rates that represent roughness and periodicity. The second modification is replacing the parametric model combining envelope and TFS measurements used in the original version with an ensemble of neural networks. The advantage is that a neural network can provide an arbitrary regression function that matches the envelope measurements to the listener intelligibility scores.

Results: The improved version of HASPI is compared to the original version for datasets from five studies of speech intelligibility. These experiments include intelligibility measured for noise and nonlinear distortion, frequency compression, ideal binary mask noise suppression, speech modified using a noise vocoder, and speech in reverberation. The new version of HASPI is shown to have significantly reduced RMS error compared to the original version for much of the data considered, and to be significantly more accurate for speech in reverberation.

Conclusions: In previous research, HASPI has been shown to be an accurate predictor of speech intelligibility, and it is one of the few metrics that have been designed and validated for hearing impairment and hearing aids. The modified version of HASPI improves its accuracy, particularly for monaural intelligibility of speech in reverberation.

Poster # 140

Efficacy of 'HeRO' Application Program by Solomon Four Group Design

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Objectives: Since some of previous studies on auditory training had not been statistically analyzed or some failed to have systematic study design, many contemporary researchers argue that effects of the auditory training are not precisely analyzed. Thus, it needs to suggest that randomized controlled trial studies with high quality should apply for a field of the aural rehabilitation. In this light, the present study aimed to evaluate the effect of auditory training while applying for Solomon four group design with both internal and external validities.

Design: A total of forty old adults with mild-to-moderate sensorineural hearing loss participated and randomly classified into four groups (e.g., A, B, C, D) who had 10 subjects per a group. In the Solomon four group design, the group A conducted pre-test, 4-weeks auditory training, and post-test. As the control groups, the group B involved in two tests before/after training, the group C worked for 4 weeks training and post-test, and the group D only participated to the post-training test. While comparing the test results of four groups, we analyzed to differentiate real effect of the auditory training from no significant effect without pre-test sensation, some possible effects in the training, and no evidence of the training. As the 4 weeks training tool, the Hearing Rehabilitation for Older Adults (HeRO) program for mobile application, which consisted of four types of the auditory training (i.e., syllable, sentence, discourse, working memory) was used. In the pre-test before the training, post-test after the training, and follow-up test at 3 weeks after the training, consonant-vowel recognition, sentence recognition in quiet and +6 dB SNR conditions, working memory ability, and self-reported questionnaire were evaluated. While following a systematic and statistical flowchart for four group comparison, we performed 2 x 2 factorial analysis of variance.

Results: There was significant interaction between auditory training and pre-test results in the consonant recognition, sentence recognition in quiet and noisy background, working memory ability using forward and backward digits. Among those tests, the consonant recognition, sentence recognition in quiet and noise, and result of backward digit showed statistically significant main effect on groups A and B and groups C and D, which explaining the 4-weeks training was effective. However, the digit forward test to see working memory ability did not prove rehabilitation effect without pre-test involvement. Vowel recognition and self-report results which had no significant interaction between the training and pre-test showed certain rehabilitation effect and no evidence of the training, respectively, because of no significant difference between groups C and D. Fortunately, results of the post-test were consistently maintain at 3 weeks after completing the training in the groups A and C.

Conclusions: Based on the current results of forty hearing-impaired old adults using m-health technique, their ability on consonant and sentence recognition and working memory was improved with 4-weeks auditory training. Interestingly, when applying for Solomon four group design, the forward digit and vowel recognition tests were not real training effect which could differentiate from the previous results.

HEARING SCIENCE / PSYCHOACOUSTICS

Poster # 141

Central Auditory Mechanisms Revealed by Dichotic Listening in Noise

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Objectives: The Dichotic Digits Test (DDT) evaluates central auditory nervous system (CANS) dysfunction. It has good sensitivity and specificity and is used in clinics worldwide. However, the DDT shows a strong ceiling effect, which can mitigate its effectiveness. It was hypothesized that adding competing noise to the DDT could decrease the ceiling effect. Administering the DDT in binaural and monaural noise-added conditions reduced the ceiling effect and revealed some surprising effects of noise on dichotic listening. These preliminary findings could lead to development of new clinical indices for evaluating auditory processing, as well as elucidating speech-in-noise and dichotic listening mechanisms.

Design: To create dichotic listening in noise, editing software was used to add speech spectrum noise to the standard DDT at varied signal-to-noise ratios (SNRs). Speech spectrum noise was added at equivalent RMS-amplitudes to the digit presentations, creating a 0 dB SNR. The noise in the 0 dB SNR tracks was amplified to create tracks with -2 and -6 dB SNR. Noise and digit-presentation files were combined into single-track presentations with noise onset/offset synchronized to the digit presentations. In addition to the no-noise (control) condition, three experimental noise conditions at each SNR were created: binaural, monaural right, and monaural left. The control and experimental conditions were presented randomly to 20 normal hearing subjects at 50 dB sensation level (re: SRT). These procedures will yield six separate conditions at each SNR, for which performance can be analyzed and multiplicative assessment algorithms have been developed.

Results: Preliminary results for the no-noise condition were consistent with published norms for the standard DDT. As expected, adding -2 dB SNR noise reduced the ceiling effect on the standard DDT, with lower combined scores in the binaural noise condition and both monaural noise conditions. Adding binaural noise showed smaller effects on combined and individual ear scores than adding monaural noise at the same SNR to either ear, demonstrating a binaural advantage for listening in noise. While preliminary results did not show a marked right ear advantage (REA) in the control condition, the -2 dB SNR binaural noise-added condition showed higher right ear scores, indicating a REA for speech in binaural noise. By contrast, the -2 dB SNR competing monaural noise conditions showed right ear scores to be lower than left ear scores. Scores at -6 dB SNR appear to show a similar but far more pronounced effect.

Conclusions: Our findings suggest a separation of speech-in-noise and dichotic listening processing effects, which presents a new view on attention versus sensory interactions in dichotic listening. The reported enhanced REA in noise and marked differences for binaural and monaural noise suggest a diminished role for attention and an increased influence of sensory processes in dichotic listening. Preliminary findings also suggest that assessing dichotic listening patterns in noise could add sensitivity to evaluations of CANS integrity. The noise-added DDT remains clinically efficient, like its standard counterpart; however, emerging data could make it more sensitive to neural mechanisms underlying auditory processing dysfunction.

Poster # 142

Does Visual Speech Provide Release from Perceptual Masking in Children?

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Objectives: Adults use visual speech as a grouping cue to help perceptually segregate a target talker from other talkers in a speech masker. Therefore, they benefit more from visual speech in a speech masker than in a noise masker. The purpose of this study was to investigate whether children use visual speech to perceptually separate a target from other talkers in a speech masker. We hypothesized that children demonstrate greater audiovisual benefit to speech recognition in the presence of a two-talker speech masker than in the presence of a noise masker. A secondary objective was to assess whether adults and children can use visual speech rhythm to direct attention in time. We hypothesized that adults and children can use rhythmic information conveyed by an audiovisual carrier phrase to predict the timing of upcoming auditory information and subsequently improve speech recognition.

Design: Ten adults (19-35 years) and fifteen children (7-9 years) with normal hearing and normal or corrected-to-normal vision were tested using a coordinate response task. Target stimuli consisted of the phrase "Now you will go to [color] [number]." Participants selected the color and number from a grid on the screen. A two-down, one-up adaptive procedure was used to estimate speech recognition thresholds in two maskers (speech-spectrum noise and a two-talker babble) and three visual cue conditions (an auditory carrier phrase with an auditory target, an audiovisual carrier phrase with an auditory target, and an audiovisual carrier phrase with an audiovisual target). Participants also completed the same task in visual only conditions. Data were analyzed using linear mixed modeling.

Results: Visual cues improved children's performance equally in both maskers. In the two-talker masker, adults recognized the auditory target better when it followed an audiovisual carrier phrase than when it followed an auditory carrier phrase. Children did not benefit from the audiovisual carrier phrase. Individual differences in children's speechreading accuracy were correlated with individual differences in their audiovisual benefit in both maskers.

Conclusions: The rhythmic information provided by visual speech in the audiovisual carrier phrase helped adults to separate the target talker from other talkers in the speech masker and predict the timing of upcoming auditory information. Results fail to support the hypothesis that children use visual speech as a grouping cue to help perceptually separate a target from other talkers in a speech masker. However, it is possible that children used different visual cues across the two masking conditions to achieve similar audiovisual benefit.

Poster # 143

Effects of Contralateral Stimulation on Low-Frequency Cochlear Microphonics
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Objectives: We hypothesize that the cochlear microphonics can be suppressed with contralateral noise. The objective of the study is to investigate a question "whether or not the cochlear microphonics can be suppressed with contralateral noise". It is known that suppression of otoacoustic emissions by contralateral noise stimulation has been well studied, but not of the cochlear microphonics yet. The studies on otoacoustic emission suppressions have demonstrated strong professional relevance of such suppression to the audiology field such as in the efferent system, bilateral decussation, brainstem lesions, hearing protection, listening attention, signal to noise ratio, otoacoustic fine-structure, etc. The otoacoustic emission is a cochlear response while the cochlear microphonic is also, although one is acoustic while the other is electrical. With both types are cochlear response, studying otoacoustic emissions is only half of the story. For another half of the story, i.e., the suppression of cochlear microphonics, we have not identified the related reports on human subjects. So, the

study is to fill the gap, being novel. The theoretical and scientific rationale is justified naturally by the importance and strong professional relevance of the suppression to the audiology field as listed above, on the cochlear microphonic being also a cochlear response, and on our study filling the gap.

Design: Explicitly, the paired samples t-test design is used because such test can compare two means that are from the same individuals, and can also determine whether there is statistical evidence that the mean difference between paired observations is significantly different. To test our hypothesis, the mean of all measured cochlear microphonics without contralateral noise is compared with that of all with contralateral noise from the same individuals. Approved by the University Institutional Review Board, from 5 young adults with normal hearing recruited voluntarily, the cochlear microphonics of both ears to low frequency tonebursts were recorded via a canal electrode with contralateral noise and also without the noise. For validation, no cochlear microphonics were measured with the toneburst sound blocked.

Results: The peak-to-peak amplitudes of cochlear microphonics were 14% smaller in average from the measures with contralateral noise than without. We assume above-1000 Hz as mid/high frequencies, so, at low frequencies (500 Hz and 1000 Hz), the difference is statistically significant ($p< 0.05$) when comparing the two means, i.e., with contralateral noise and without. When comparing the measures only at 500 Hz, the difference is also significant. When further comparing only at 1000 Hz, the difference is still significant. Additionally, for one side only such as right ears, the difference between without and with the noise is significant as well; so is for the left ears.

Conclusions: The results indicate that (besides the otoacoustic emissions) the cochlear microphonics can also be suppressed. The mechanism, although unconfirmed, is likely similar to that of otoacoustic emission studies, i.e., via the efferent (effects) on the outer hair cells. This study may help both develop a new pediatric/diagnostic approach in clinics and a new area in research, for its implications/applicability in the audiology field as listed above (i.e., efferent, attention, among others).

Poster # 144

Relation between Personal Listening Devices and Hearing Thresholds: A Meta-Analysis

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Objectives: With an increasing trend in the usage of personal listening devices, many concerns have been raised over the potentially hazardous impacts to the auditory system of users. Although conducted by many researches, those negative hearing impacts are still unclear and/or have some different outcomes between preferred listening levels and users' hearing insults. The present study aimed to explore scientific evidence whether the listening levels and duration of music exposure might affect hearing thresholds in adolescents/young adults.

Design: A total of six electronic databases were searched by related keywords that divided four sub-groups; 1) personal listening devices, 2) listening intensity and duration, 3) hearing thresholds and symptoms, and 4) age. After removing 477 duplications, 2505 articles remained. The articles were screened as either abstract or the full-text and classified based on our inclusion criteria. Then, the quality of the study was evaluated by using the Newcastle-Ottawa scale. Finally, a total of 18 studies were qualified and included for the systematic review and meta-analysis. The standardized mean difference, its 95% confidence intervals in audiometric results (e.g., PTA and DPOAE) of the device users, and the weight were estimated and stratified by study design, frequency, listening level, and duration. A Higgins I2-statistics and Q statistics were used for checking the heterogeneity. A

random-effect model was used when assumed to be heterogenous with subgroup analysis of moderator (listening level and duration). To test the publication bias, funnel plots were drawn with Egger's regression.

Results: A total of 18 studies were divided into two groups to see namely, short-term effect (pre/post-exposure; n =7) and long-term effect (device users/non-users; n =11). In the studies with short-term effect, pure-tone thresholds at 4 kHz showed relatively the highest effect size (2.1523, 95% confidence interval: -1.4141 - 5.7188), while the thresholds at 4 kHz showed the high heterogeneity (I2: 75.2%) and the thresholds from the other frequencies showed less than 10% I2. DPOAEs also showed the highest effect size at 4 kHz (-0.5998, 95% confidence interval: -1.4849 - 0.2864). On the other hand, the studies with long-term effect showed more than 50% I2 except for the pure-tone thresholds at 8 kHz which had the highest effect size (3.3945, 95% confidence interval: 2.1248 - 4.6642). But DPOAEs showed the highest effect size at 4 kHz (-0.8961, 95% confidence interval: 02.8065 - 1.0884). Although distribution of funnel plots had $p > 0.05$ in most of studies, the pure-tone thresholds at 8 kHz in short-term effect and those at 4kHz in long-term effect significantly showed $p = 0.0471$ and $p = 0.0215$ results in the regression, respectively.

Conclusions: Effect size of the short-term effects was revealed at a specific 4 kHz, but that of the long-term effect affected at two frequencies of 4 and 8 kHz with a high effect size. Our results imply that overusing of the personal listening devices acts on potential changes of thresholds in audiometric testing. Further, when using the listening devices longer, these effects might be extended to neighbor frequencies around at 4 kHz with certain degree of hearing loss.

Poster # 145

Chemotherapy and Aminoglycoside Treatments: Ototoxic Effects in Pediatric Cancer Patients
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Objectives: In the United States, brain and central nervous system tumors are the second most commonly diagnosed cancer in children. Treatment of these tumors can vary between patients and often involve a combination of chemotherapy, radiation, and/or surgery. These treatments may be used in combination with aminoglycoside antibiotics for management of serious infections that can occur while treatment is in progress. Ototoxic properties have been documented in the literature in humans for platin-based chemotherapy (e.g., cisplatin or oxaliplatin), head and neck radiation, and aminoglycosides. While these therapies in isolation have been studied extensively, there is limited evidence about the impacts on the auditory system of exposures to both chemotherapy and aminoglycosides. The objective of this study was to determine if the use of aminoglycosides in conjunction with chemotherapy are more likely to cause an earlier CTCAE Grade v4.03 or ASHA (1994) Significant Threshold Shift (STS) than those with chemotherapy and/or radiation alone. It is hypothesized that there is greater ototoxicity, both cochleotoxicity and vestibulotoxicity, when these treatments are used in combination for children with brain tumors. We aim to highlight the prevalence of aminoglycoside use in this population as well as the incidence and rate of hearing loss and vestibular symptoms.

Design: This study analyzed retrospective data for 352 individuals (age<18 years) undergoing brain cancer treatments between 2000 and 2013 at the Mayo Clinic in Rochester, Minnesota. Sixty-six individuals were included in the study as they had been seen for at least two audiologic evaluations and received at least one of the following treatments: carboplatin, cisplatin, and/or head and neck radiation. The individuals were divided into two groups, one with aminoglycoside use and one without. Examined variables include: chemotherapy treatment (types/dose/frequency), aminoglycoside use/type, audiometric thresholds (up to 20 kHz), otoacoustic emissions, tympanometric results, and balance concerns.

Results: Treatment with an aminoglycoside was found in 56.1% of individuals (n=37), with the most common being vancomycin (97.2%) and second gentamicin (19.4%). Individuals that had been treated with aminoglycosides had a higher incidence of a gradable change in hearing from baseline (75.7 %). The majority of STS for both groups occurred within the first 12 months following initial treatment. Balance concerns were seen in 75.8% of all individuals, with gait and imbalance concerns being the most common. Individuals who had taken an aminoglycoside had a higher incidence of balance concerns (86.5%) than those with chemotherapy alone (62.1%).

Conclusions: Results highlight the importance of ototoxic monitoring in pediatric patients with brain tumors. Aminoglycoside use is prevalent in this population and effects of aminoglycoside use in conjunction with chemotherapy should be taken into consideration during an audiologic evaluation. Balance concerns are common in pediatric patients with brain tumors and may have a higher likelihood if also taking aminoglycoside antibiotics. Future prospective studies are needed to assess the effects of aminoglycoside use in combination with chemotherapy.

Poster # 146

Using Wearable Sensors to Measure Listening-related Stress: A Validation Study
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Objectives: In addition to increased stress due to effortful listening, people with hearing loss deal with psychosocial stressors such as embarrassment, stigma, and other social consequences related to hearing difficulties in daily life. Laboratory studies have measured changes in arousal due to increased listening effort using psychophysiological measures like changes in pupil dilation, heart rate, respiration, and skin sweat; however, these lab measures do not reflect listening-related stress in daily life. This research sought to provide evidence that commercially available, wearable sensors can provide valid information about psychophysiological stress associated with difficult listening.

Design: Sixteen young adults with normal hearing sensitivity participated in a within-subjects repeated measure study. Participants repeated key words in response to speech stimuli of varying degrees of difficulty. Key words were embedded in sentences that had high and low levels of context and were presented at 4 different signal-to-noise ratios (SNRs). To mimic a psychological stressor similar to negative consequences of misunderstanding speech in a natural listening environment, a flash of light was presented for incorrect answers for half of the presentations and participants were informed that their monetary reimbursement would be reduced as a consequence of incorrect responses. While collecting speech understanding information, psychophysiological arousal was simultaneously measured using laboratory grade and wearable measures of heart rate, respiration, and skin conductance. Participants were asked to report their perceived arousal, valence, and workload to using the Self-assessment Manikin (SAM) and National Aeronautics and Space Administration Task Load Index (NASA-TLX) at the conclusion of each test trial.

Results: Results of preliminary analyses demonstrated that speech understanding, and self-reported measures reflected expected differences between high- and low-context items and among the four SNRs. Self-reported measures showed increased workload, arousal, and more negative valence with psychological feedback. Calculations of effect sizes for physiologic measures showed that one or more wearable sensors were able to detect at least a medium effect for each condition. Effects were mostly in the same direction as those measured with lab sensors, validating these data. Some of the psychophysiological findings were in the opposite direction

of self-reported arousal ratings. Specifically, on average, participants reported less arousal when keywords were embedded in high context sentences, yet psychophysical measures showed increased arousal with additional linguistic context.

Conclusions: These early findings suggest that wearable sensors are able to provide valid information about physiological states in response to difficult listening. It is of interest that some psychophysiological effects were in the opposite direction of self-reported arousal ratings. It is probable that using additional cognitive resources to fill in keywords with contextual information resulted in better speech understanding and that participants perceived that the task was easier to complete. Although this commonplace activity was not perceived by participants to be effortful, the active use of additional linguistic information required increased vigilance and cognitive effort which was reflected in the psychophysiological measures. These findings support a recommendation for using multiple methods to gain a more complete picture of the effort needed for difficult listening.

Poster # 147

Physiological Changes in Macaque Monkeys Following Noise-Induced Cochlear Synaptopathy

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Objectives: Recent studies have shown that normal aging and/or acoustic overexposure can lead to a significant loss of inner hair cell ribbon synapses without loss or damage to inner or outer hair cells, changes to auditory brainstem response (ABR) thresholds, or distortion product otoacoustic emission (DPOAE) amplitudes. Such cochlear synaptopathy may subserve the clinical presentation of difficulty hearing in noisy environments despite a normal audiologic exam. However, the behavioral and physiological indicators of cochlear synaptopathy have not yet been identified. We used our recently developed nonhuman primate (NHP) model of hearing loss to examine cochlear synaptopathy in a species that is phylogenetically similar with humans, and affords the possibility of controlled perturbations to the auditory system and histological verification of cochlear pathology. Objectives: 1) To establish normative physiological measures using a standard clinical montage in NHPs (Macaca mulatta): ABR thresholds, component amplitudes and latencies, and DPOAE thresholds and amplitudes. 2) To examine the changes in physiological measures following noise exposures causing cochlear synaptopathy in NHPs.

Design: Physiological characterizations were made in normal hearing control subjects (N=10) and noise exposed subjects that had also been characterized pre-exposure (N=3) using the following metrics: DPOAEs (8 points/octave; f2 = 0.5-10 kHz; f2/f1 = 1.22), measured over L2 = 20-70 dB SPL in 5-dB steps; ABRs (vertex-to-mastoid, ground at shoulder) to tone pips (0.5 - 32 kHz) and clicks presented 27.7/s were measured over 10-90 dB SPL (5- or 10-dB steps); and ABRs to click pairs (70-90 dB SPL in 10-dB steps) presented at varying interclick intervals (ICI; 10 to 1 ms). Cochlear synaptopathy was induced by dichotic exposure to an octave band noise (OBN, 2 - 4 kHz) at 120 dB SPL for 4 hours.

Results: (Objective 1) ABRs in NHPs were characterized by three major waveforms (Waves I, II, and IV), comparable to waveforms in the human ABR (Waves I, III, and V). NHP ABR Wave I amplitudes increased with stimulus sound pressure level; Wave I latencies decreased with increasing stimulus frequency and sound

pressure level. Consistent with human ABR data, Wave I amplitudes were variable between subjects and even across ears of the same subjects. In the paired-click regime, click 2 Wave I amplitude (re: click 1 Wave I amplitude) decreased as ICI decreased.(Objective 2) Immediately post-exposure, DPOAE thresholds were temporarily elevated (up to 40 dB), but recovered fully by 8-weeks post-exposure. ABR thresholds 8-weeks post exposure were not different re: pre-exposure. However, suprathreshold ABR Wave I amplitudes were reduced at frequencies higher than the noise exposure frequencies, including regions of expected synapse loss. In the paired-click paradigm, click 2 Wave I amplitude (re: click 1 Wave I amplitude) were reduced at longer ICIs relative to pre-exposure, suggesting a slower recovery of click 2 responses after synaptopathic noise exposures.

Conclusions: Preliminary evidence suggests that suprathreshold ABR Wave I amplitudes and suprathreshold paired click Wave I amplitude ratios may be sensitive to noise-induced cochlear synaptopathy. Future work will help to confirm these and identify additional electrophysiological diagnostics for cochlear synaptopathy. [Supported by NIH-NIDCD T35 DC 08763 (PI: L. Hood) and R01 DC 015988 (MPI: R. Ramachandran and B. Shinn-Cunningham).]

Poster # 148

Detection of Ear Canal Impedance for Improved Otoacoustic Emission Measurements

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Objectives: One source of variability in Distortion Product Otoacoustic Emissions (DPOAE) measurements is probe position in the ear canal, which can vary from visit to visit, and lead to apparent emission shifts. This sensitivity is particularly pronounced at frequencies of 3 kHz and above, where standing waves in the ear canal can radically affect the levels of the stimulus and of the measured emission. Recent literature has shown that forward pressure level (FPL) calibration appears to be the optimal estimation method to minimize the effects of standing waves in the determination of the acoustic stimulus to the cochlea. Existing probe microphone systems that estimate the forward pressure level, use a model-dependent “Thévenin” calibration to estimate acoustic impedance in the ear canal using acoustic pressure measurements. Here, we present the results of a prototype device that directly estimates the acoustic impedance of the ear canal using both acoustic pressure and velocity measurements. The objective of the study was to evaluate the new probe sensor system by comparing measurements of impedance and DPOAEs made with it to measurements made with an Etymotic ER10X probe microphone system.

Design: Participants. 21 adults, ranging in age from 23 to 67 years old, participated in the study. 11 participants had normal hearing (thresholds were<15 dB HL at frequencies between 250 and 8 kHz) and 10 participants exhibited hearing loss. All had normal middle ear function in the test ear on the day of testing.Prototype. The prototype probe used two Etymotic ER-2 earphones and a MicroFlown acoustic particle velocity sensor collocated with a microphone inside a 7mm tube. The tube was sealed to the ear canal with stethoscope eartips. The probe head was mounted to headband that forced the tip against the ear canal opening. The electronics for processing the signals were located in a box attached to the headband and the device was controlled wirelessly through Matlab. Procedure. During the first visit, measurements included both ear canal impedance and DPOAEs. Impedance measurements used a wideband linear-sweep chirp between 0 and 24kHz with a duration of 171msec DPOAEs were elicited at seven primary frequencies f1 and f2 (f2=1, 1.5, 2, 3, 4, 6, 8 kHz) with an

f2/f1 ratio of 1.22 and levels of 65/55 dB SPL. Impedance and DPOAE measurements were repeated at a second visit to evaluate reliability (prototype only).

Results: The validation study indicated that the prototype performed similar to the ER-10X for DPOAE measurements (absolute DP level). Test-retest reliability of the prototype was rated Good for both DPOAE measurements and Impedance measurements. However, the prototype impedance measurements were different from those obtained with the ER-10X.

Conclusions: This study demonstrated the feasibility of using combined acoustic pressure and velocity sensors to accurately determine forward pressure level and measure repeatable DPOAEs on both normal and impaired hearing participants. This first prototype will need additional refinement to improve the ear canal impedance measurement accuracy. With accuracy improved, development effort will then focus on usability for diagnostics in field-forward settings.

Poster # 149

Individualized Speech Intelligibility Index: Feasibility and Reliability

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Objectives: The Speech Intelligibility Index (SII) is a widely adopted model to describe speech audibility, however many parameters in the model represent speech perception characteristics across a large number of normal-hearing listeners. The predictive power of the SII model may be improved by estimating the model parameters on an individual level. The objective of the current study is to validate an adaptive procedure that estimates an individualized SII model.

Design: The SII parameters were estimated from thirty normal-hearing listeners and ten hearing-impaired listeners using a Bayesian adaptive test procedure. The SII parameters included: (1) the relative contributions from five octave frequency bands (centered at 250, 500, 1000, 2000, and 4000 Hz) to speech intelligibility, i.e. the band importance function, and (2) the transfer function that relates the SII to speech-recognition score. For each listener the estimation was repeated twice, with one week or longer in between, to examine the test-retest reliability. The test procedure involved presenting low-context sentences in babble noise maskers and required the listener to repeat the presented target sentences. Each test run consisted of 100 trials, approximately 20 minutes of testing time. The target-to-masker ratio and spectral filtering were adaptively determined before each trial to maximize information gain. For hearing-impaired listeners, the stimuli at conversational speech level (65 dB SPL) were amplified and spectrally shaped to ensure speech audibility, validated using real-ear sound pressure measurements. For normal-hearing listeners, three speech levels (55, 65, and 75 dB SPL) were tested.

Results: The BIFs for sentences estimated from normal-hearing listeners were relatively consistent across listeners and did not vary significantly across the three speech levels. The root-mean-square deviation between the test and retest in terms of the relative weight in each of the five bands was on average 4.78% (SD: 1.80%). Across the ten hearing-impaired listeners, the shape of the BIF varied greatly, which cannot be fully explained by the shape of their audiograms. The root-mean-square deviation between the test and retest in terms of the relative weight was on average 4.95% (SD: 2.74%). The transfer function, in terms of the SII that corresponds to a 50% keyword recognition performance, was highly reliable for both listener groups.

Conclusions: The Bayesian adaptive procedure evaluated in the current study is sufficient in capturing the individual differences in the BIF and transfer function for the SII model for both normal-hearing and hearing-

impaired listeners. Therefore, the procedure may be used to capture individual differences in speech understanding beyond those predicted by the audiometric results.

Poster # 150

Middle Ear Pressurized Laser Doppler Vibrometry and Wideband Absorbance Measures
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Objectives: The objective was to obtain the first laser Doppler vibrometry measures of middle ear function at various ear canal air pressures for comparison with pressurized wideband absorbance measurements in subjects with normal hearing or sensorineural hearing loss.

Design: Laser Doppler vibrometry (LDV)measurements were obtained at ambient pressure, tympanometric peak pressure (TPP) and ±100 and ±200 daPa in 15 subjects with normal hearing or sensorineural hearing loss. Measures of wideband acoustic immittance (WAI) were made at the same pressure conditions for comparison in the same subjects. This is the first report of pressurized LDV measurements with the goal of increasing the clinical applicability of the technique for use in patients with middle ear over-or under-pressure, and for comparing these measurements with WAI in the same conditions. LDV measures the sound-induced umbo velocity (Vu) of the malleus. LDV measurements were completed with a Polytec OFV 534 laser vibrometry unit (Polytec Inc.) that was modified to prevent air-pressure leaks. The complex acoustic stimulus had a frequency range from 300 to 6000 Hz. Custom ear specula that have a port for the introduction of air pressure changes in the ear canal were constructed using a 3D printer. Air pressure was varied using the pressure pump from a GSI tympanometer connected to the speculum with standard tubing. WAI measurements were obtained in the same ear-canal pressure conditions using an Interacoustics Wideband Research System and personal computer (PC). The probe was a click with a frequency range of 0.25 to 8.0 kHz. The PC generated digital stimuli and recorded digital responses from the probe under custom software using a 24-bit sound card. An additional port exiting the probe coupled air pressure changes delivered by a pump and pressure controller in an AT235 tympanometer to achieve the desired pressure under the control of the custom software for measurements at ear canal air pressures of ambient, TPP, ±100 and ±200 daPa.

Results: Mean Vu and wideband absorbance were reduced at frequencies below 2000 Hz with increasing or decreasing ear canal pressure similar to changes we have previously reported for absorbance in adults. Mean Vu at TPP showed an increase in Vu and absorbance compared to ambient pressure at frequencies below 2000 Hz.

Conclusions: The results suggest that pressurized measures of LDV will be useful clinically in compensating for middle ear over-or under-pressure similar to reports for wideband absorbance. Planned studies will examine these measures in patients with an intact tympanic membrane and conductive hearing loss to evaluate the benefit of pressurized measures compared to ambient-pressure measures for detecting middle ear disorders.

Poster # 151

Working Memory Load in Auditory Processing Tests Among Veterans
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Objectives: Many Veterans with histories of blast-exposure and likely mild traumatic brain injury (mTBI) report hearing impairments despite normal standard audiometric performance. Post-traumatic stress disorder (PTSD) is frequently comorbid with mTBI. These Veterans often suffer from cognitive fatigue, hypersensitivity, and hypervigilance, which limit access to and use of cognitive resources for memory demanding tasks. Evidence suggests that this population's auditory complaints relate to impairments of the central auditory processing (CAP) system. Common CAP behavioral assessments vary in working memory load, and those differences remain unclear. The research objective was to examine the role of working memory on the performance of Veterans with and without mTBI and PTSD on commonly administered auditory processing tasks. Compared to healthy controls, Veterans with mTBI and/or PTSD were predicted to: (1) exhibit poorer verbal working memory; and (2) with all groups combined, group largely into a low- rather than high-memory group when split by working memory performance. Further, we hypothesized that the low- and high-memory groups' performance on auditory processing tasks would differ based on the tasks' working memory loads.

Design: Veterans (n=198) aged 20-50 years with normal or near-normal pure-tone thresholds were enrolled into mTBI-only, PTSD-only, mTBI+PTSD, and control groups based on blast-exposure history, self-reported hearing handicap, and PTSD. Participants completed a comprehensive CAP test battery. Verbal working memory was measured using the backward Digits Span Test (DST) and the more semantically demanding Rey Auditory Verbal Learning Test (RAVLT). Using median splits, scores on the DST and RAVLT were used respectively to split Veterans into low- and high-memory groups, which were subjected to between group comparisons on the CAP tests.

Results: Compared to controls, Veterans with mTBI, PTSD, or mTBI+PTSD performed similarly on the DST and RAVLT. That said, when using DST as the splitting criterion, most Veterans with mTBI+PTSD classified as low-memory. When using RAVLT as the splitting criterion, most Veterans with mTBI+PTSD or mTBI-only classified as low-memory. For both criteria, the remaining groups split evenly between low-and high-memory. Compared to the low-memory group, the high-memory group performed: 1. Better on 4/9 tests: dichotic digits (DDT), staggered spondaic words, words in quiet (WIQ), and words in noise (WIN), when split by DST.2. Better on 5/9 tests: DDT, gaps in noise, WIQ, WIN, and Listening in Spatialized Noise-Sentences, when split by RAVLT. 3. Similarly on 3/9 tests: masking-level difference (MLD)-tone, MLD-speech, and competing sentences, regardless of the splitting criterion.

Conclusions: Although Veterans with mTBI-only, PTSD-only, or mTBI+PTSD did not differ statistically from controls on the DST and RAVLT, most Veterans with mTBI+PTSD or mTBI-only grouped as low-memory when split by DST or RAVLT, implicating contributions of mTBI+PTSD or mTBI on verbal working memory. Similarities between low- and high-memory groups on 3/9 tasks suggest that these tasks may require fewer verbal memory resources than the other measures. Alternatively, Veterans with poor working memory may

suffer from unexamined comorbid pathologies that manifest in measures where high-memory advantages were observed. These findings provide a preliminary examination of the target populations' working memory abilities and implications for CAP and CAP testing.

Poster # 152

Use of Entropy to Quantify Real World Listening Environments

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Objectives: In this study, we investigated preliminary uses of entropy to quantify complexity in real world listening environments. In acoustics, entropy measures the average rate of change in the time or frequency domain and provides an objective measurement of the complexity of or amount of information in the communication system. We also investigated the relationship of entropy to speech perception and listening effort in complex listening environments. We hypothesized that listening performance would decline with increases in entropy. We further hypothesized that entropy would serve as a better indicator of listening performance than environment classification, the typical processing approach used by hearing aids. Finally, an exploratory analysis was completed to examine the nature of hearing aid feature activation in the real world based on overall level compared to entropy.

Design: Data from two larger studies were analyzed for the current study. In each of the larger studies, data was collected in the real world using sound recordings made by recording devices and ecological momentary assessments (surveys delivered in-situ on smartphones). The first study comprised 20 adult hearing aid users. Each participant completed ecological momentary assessments over the course of a month and each assessment was paired with a recording made by a portable recording device. The second study comprised 10 participants who completed ecological momentary assessments paired with sound recordings from a recording device over one week. In the second study, each participant wore research hearing aids and the hearing aid processing data was collected by the participant’s smartphone in real-time. Overall levels and time-domain entropy measurements were calculated using the sound recordings. Entropy measurements were paired with the momentary assessments and, if available, hearing aid processing data.

Results: Listening effort reliably increased with increases in entropy. Speech perception reliably decreased with increases in entropy. The effect of entropy on listening effort was greater than the effect for speech perception. Overall level was associated with entropy, though entropy may be a better predictor of listening performance in environments with similar overall levels. Quiet and noisy environment classes demonstrated clear differences in entropy; however, among noisy environments, there was not a clear differentiation of entropy among environment classes. Hearing aid data suggests that hearing aid directionality may react more to overall level than entropy.

Conclusions: This study served as a preliminary investigation into the use of entropy to describe complex listening environments and predict listening performance and hearing aid feature activation in the real world. Entropy is a reliable predictor of listening performance. It may be better able to explain differences in listening performance than overall level, in part due to the possible relationship of entropy to temporal masking and auditory attention. The entropy approach may provide a useful theoretical groundwork for better understanding how hearing aids and hearing aid users function in complex listening environments.

Poster # 153

A Rapid Procedure for Measuring N0S Detection Thresholds

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Objectives: The need for measures beyond the audiogram is critical in DoD hearing conservation settings where individuals are at increased risk of hidden hearing loss. The binaural masking level difference (BMLD), and in particular the N0S detection threshold, is adversely affected by blast exposure. Wilson et al. (2003) [J. Am. Acad. Audiol. 14, 1-8] proposed a 33-trial yes/no procedure to measure the BMLD in a clinical population. When used in a DoD hearing conservation setting with service members (SMs) with normal hearing thresholds, 6 of the 12 N0S trials were detected by over 97.5% of the SMs and are essentially uninformative. The purpose of this research was to develop a novel procedure that is more efficient at measuring the N0S detection threshold in individuals with normal hearing thresholds.

Design: Three different yes/no procedures were tested in addition to the Wilson procedure. The first two procedures consisted of 8 N0S trials and 2 N0 catch trials. The N0S trials used the stimuli from the eight trials with the lowest signal-to-noise ratios (SNRs) from the Wilson procedure. These new procedures removed all of the N0S0 trials, a number of the N0 trials and a few of the easiest N0S trials. One of the procedures presented these trials in an order with monotonically decreasing SNR while the other procedure presented the same SNRs in a random sequence. A total of 62 subjects were tested with both procedures in a random order. The third procedure includes 14 N0S trials and 4 N0 catch trials presented in a fixed order but with a non--monotonic sequence of SNRs. This procedure included the full range of SNRs from the Wilson procedure, but the distribution of the SNRs was different. A total of 761 subjects were tested with this procedure alone and 209 subjects were tested with both the non-monotonic ordered procedure and the Wilson procedure in a random order.

Results: A repeated measures ANOVA on the thresholds obtained with the monotonically ordered and random ordered procedures revealed no main effect of order or procedure, but did reveal a statistically reliable interaction indicating rapid learning. Further, an independent sample t-test between the thresholds from the first procedure tested and previous data from the Wilson procedure showed reliably reduced performance with the modified procedures. A repeated measures ANOVA on the thresholds obtained with the non-monotonic order procedure and the Wilson procedure revealed a main effect of procedure but no effect of order or order/procedure interaction. The average difference in threshold between the two procedures was only 0.7 dB which is likely not clinically significant.

Conclusions: These results suggest that removing trials that led to near perfect performance with the Wilson procedure reduced performance on the harder trials. Overall, the non-monotonic order procedure reduced the number of trials required while preserving, and often improving, the desirable qualities of the Wilson procedure. Having tested nearly 1000 SMs in a hearing conservation setting with less than 1% of SMs unable to complete the test, we think the modified procedure can be used as a rapid tool for helping to detect hidden hearing loss.

Poster # 154

Optimal Frequency Ratio for Evoking High-Frequency DPOAEs in Children

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Objectives: Distortion Product Otoacoustic Emissions (DPOAEs) provide an objective measure of outer hair cell function and are well-studied at conventional frequencies (< 8 kHz) in neonates, infants, children, and adults. The frequency ratio (f1/f2) evoking the largest level DPOAE, referred to as optimal, does vary with frequency. However, a ratio of 1.22 generates DPOAEs over a broad frequency range. The optimal ratio for specific frequencies has been determined for term and premature neonates and adults. The aim of this study is to define the optimal frequency ratio generating DPOAEs and determine its repeatability in younger and older children for conventional and high frequencies (> 8 kHz). It is hypothesized that as frequency increases the optimal ratio evoking the largest DPOAE level will be less than 1.2 and that the optimal ratio will be repeatable across trials.

Design: DPOAE ratio sweeps (f2/f1 = 1.1 to 1.25; L1/L2=65/50 dB SPL) were collected and repeated (n=4) at various fixed frequencies in 76 children, ages 3-6 and 10-12 years. The older children were tested at low and high frequencies (f2=2-16 kHz), while the younger children were only tested at high frequencies (f2=10-16 kHz). Each child was tested on four different occasions, ideally separated by one week. Depth-compensation calibration methods were used.

Results: The optimal frequency ratio evoking the largest DPOAE level decreased as frequency increased. A narrower ratio than the typical 1.22 was optimal for frequencies greater than 4 kHz and results were similar for all children tested. Collapsed across frequency (10-16 kHz), the optimal frequency ratio was 1.175 and 1.167 for older and younger children, respectively. No significant differences were found between trials in the optimal frequency ratio for all children.

Conclusions: Similar to adults, the optimal frequency ratio evoking the largest DPOAE level decreases as frequency increases in children. This is critical to establish reliable and clinically useful DPOAE interpretations in children.

Poster # 155

Role of Memory and Language in Children's Auditory Closure Ability

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Objectives: Understanding individual variability in auditory closure provides insight into children's ability to communicate effectively in adverse listening situations. We studied the role of language and cognitive mechanisms in school-age children's auditory closure ability because this has implications for children with language disorders. It was predicted that lexical access and knowledge measures would play a more significant role than short-term memory/working memory capacity in auditory closure.

Design: Perceptual restoration of missing speech is called auditory closure. We employed the time-gated interrupted speech paradigm to measure auditory closure ability in sixty-seven, 8- to 11-year-old children. Children who passed pure-tone hearing screening, nonverbal IQ screening, and articulation screening received multiple measures. Auditory closure tasks: Auditory closure was measured using sentences (Bamford Kowal Bench) and words (Lexical Neighborhood Test that included mono and multi-syllabic, lexically easy and hard words). Sentences and words were interrupted using 50% duty cycle square wave at the rate of 2.5 Hz. This created alternating segments of 200 ms of clean speech and 200 ms of silent intervals. To minimize distortion from abrupt gating of speech, 5-ms raised cosine ramps were applied to the onset and offset of the square wave.

The silent intervals were filled with speech shaped noise which was 8dB higher than speech, to restore perceptual continuity. Children were asked to repeat the time gated sentences and words. Outcome was percent correct recognition.Memory tasks: Non-word repetition – a knowledge/background independent measure of phonological short-term memory (STM). Children heard 1- to 4- syllable nonwords (e.g., /naib/) and repeated each nonword. Outcome was recall accuracy.Digit WM task - Children saw a single-digit number followed by a screen with two red squares. They judged if the squares were same/different using a touch screen response. Next, another digit appeared followed by another pair of squares. After a set of items, the child recalled the numbers on a 3x3 grid on the screen. There were 2 to 5 items with three trials at each length. Outcome was total digits recalled in correct order.Language tasks:Lexical knowledge - A standardized receptive vocabulary test indexed children's knowledge of single words and word associations. The child pointed to one of 6 pictures that best matched a spoken word. There were ten picture templates/semantic categories. Outcome was total accuracy.Long-Term Memory (LTM) access Retrieval fluency - Woodcock Johnson III Test of Cognitive Abilities. Children named quickly as many exemplars as possible within a category (e.g., animals) in one minute. Three categories were scored. Outcome was total accuracy.Semantic priming task: Children heard five monosyllabic words from two semantic categories ("cat, bus, dog, truck, boat"). Next, they answered which category items were more in number via touch-screen ("Were there more animals or vehicles?"). Finally, they heard word pairs and judged whether they belonged to the same semantic category or not. Words were from the five presented words, semantically related words but not presented, or unrelated words. Examples: Primed Direct: boat-truck; Primed-Indirect: car-horse; Unprimed: slide-swing. Three sets of five words and associated trials occurred. Outcome was total accuracy from category judgments on primed direct and primed indirect trials.

Results: Three separate step-wise regression analyses were performed using percent correct recognition as the dependent variable (auditory closure ability) for sentences, lexically-easy, and lexically-hard words, respectively. Age was always controlled for first. Memory measures (NWR and WM) were entered second, lexical knowledge (receptive vocabulary) was entered third, and LTM access measures were entered last.Results for sentences suggested that STM/WM did not explain significant variance in auditory closure, but lexical knowledge explained 6.2% additional variance beyond age and memory. LTM access explained 12.3% variance over and above other predictors.For lexically easy words, only lexical access from LTM explained unique variance (16%) in auditory closure, after controlling for age, memory, and vocabulary knowledge. For lexically hard-words, only lexical knowledge explained unique variance (7.8%). Results were consistent even when the order of independent variables was changed.

Conclusions: We examined the role of memory, lexical knowledge, and lexical access in children's auditory closure ability. Results suggested that children's ability to fill in missing speech information relied mainly on lexical measures (lexical access/retrieval and knowledge) rather than their memory system.

Poster # 156

Preliminary Results: Effects of Noise and Location on Spatial Acuity

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Objectives: Our research examines the impact of background noise and originating location of a target sound on spatial acuity. Difficulty understanding speech in background noise continues to be a common complaint from individuals with normal hearing and those with hearing loss. These complaints can point to deficits in the ability

to discriminate a target talker from a spatially-separated background noise. Previous work has shown that listener performance degrades in complex listening environments, and when the signal of interest is presented from peripheral locations. To determine source location, listeners utilize a combination of interaural timing and level differences cues, which are processed in the binaural auditory pathway. This presentation serves as an evaluation of pilot data as part of a larger study on the effects of aging on the sound localization pathway. We hypothesize that the effects of aging exacerbate spatial acuity perception deficits, and that these effects will vary with both the amount of background noise and location of the signal of interest.

Design: To date, 10 subjects have participated with data collection ongoing. Participants include listeners with normal hearing or a mild sensorineural hearing loss. Spatial acuity is evaluated along the horizontal plane inside a hemi-anechoic sound chamber. Participants identify the direction (left or right) of a target signal relative to a reference signal in a two alternative forced choice (2AFC) task. Signals are played in background noise with a signal to noise ratio (SNR) ranging from 0 to -12 dB. The reference signal varies across eight locations ranging from 0 to 90 degrees left or right of the target. Stimuli includes broadband noise, as well as 1 kHz and 4 kHz centered narrowband noise. Background noise includes broadband and narrowband uncorrelated noise presented diffusely.

Results: Data analysis includes individual and group psychometric functions detailing performance in varying listening conditions. The minimum audible angle, the smallest angle necessary to correctly determine the target signal direction, increases as the listening environments becomes more complex. Reference location has variable effects on performance based on listening condition.

Conclusions: Background noise negatively impacts spatial acuity. Aging exacerbates difficulties related to binaural auditory function. [Portions of this work were funded by NIH-NIDCD R01 DC017924-01A1.]

Poster # 157

Real-Time Lexical and Semantic Processing in Children with Hearing Loss

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Objectives: As a speech signal unfolds, listeners must cope with temporary ambiguity. For example, as "sandal" is heard, "san-" could be the onset of numerous lexical candidates. Normal hearing (NH) listeners immediately activate multiple candidates consistent with the speech input (e.g., "sandal," "sandwich"). Activation spreads to semantic features of these candidates (e.g., "worn on foot," "edible"), which facilitates activation of semantically related words (e.g., "sneaker," "apple"). Once enough input is available to disambiguate the target from competitors, listeners suppress phonological competitors and semantically related items. NH listeners require fast target word activation and competitor suppression to decode running speech efficiently. Prelingually deaf adolescents with cochlear implants (CIs) show a different pattern: they delay lexical access until substantial input arrives, resulting in decreased phonological competition. It is not clear how younger children with CIs, or any children with hearing aids (HAs), may differ in these strategies. The objectives of this study are to characterize the dynamics of lexical access and semantic activation during spoken word recognition in children with CIs and children with HAs. We test the hypothesis that developing language via a degraded signal causes delayed lexical access and reduced phonological competition in school-age children, regardless of the degree of degradation. We also test the hypothesis that developing language via a degraded signal leads to differences in semantic processing in children with hearing loss.

Design: Data collection is ongoing. Currently, 18 children with HAs (mild to moderately-severe hearing loss), 17 children with NH, and 3 children with CIs have participated, ages 9-12 years. Participants complete a visual world paradigm eye-tracking task. On each trial, four images appear on a computer screen. The label for one image is presented through a speaker, and the participant clicks on the corresponding image. Eye movements are recorded throughout the task. Stimuli are displayed based on three types of word relationships: cohorts, in which the words begin with the same phonology; rhymes, in which the words end with the same phonology; and semantics, in which the words share semantic features. On each trial, the paired items appear with two phonologically and semantically unrelated items. A battery of additional assessments is administered to characterize audiological, linguistic, and cognitive abilities.

Results: Accuracy on the visual world paradigm task was high (mean>98% for all groups). Preliminary analyses indicate that relative to children with NH, children with HAs are slower to activate the target word by 72 ms ($p=.002$). Bootstrap analyses indicate that children with HAs show reduced cohort activation, increased rhyme activation, and decreased semantic activation relative to children with NH ($p's<.05$).

Conclusions: Results from targets, rhymes, and cohorts indicate children with HAs demonstrate delayed real-time lexical access, a pattern previously believed to be unique to prelingually deaf CI users. Results from semantic trials suggest that developing language via any degree of hearing loss may cause weaker connections between semantically related words in a child's lexical-semantic network. The findings suggest that children with HAs may be in need of intervention aimed at strengthening lexical-semantic associations between words.

HEARING TECHNOLOGY / AMPLIFICATION

Poster # 158

Psycho-Social Benefits of Amplification
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Objectives: In 2017, researchers at the Phonak Audiology Research Center evaluated the psycho-social impact of amplification by examining the psycho-social benefits of daily wear hearing aids as well as extended wear devices (i.e. Lyric). A previous study implied that users of the Lyric devices had a more positive personal image than those of daily wear instruments. This study served to broaden the scope by using additional questionnaires and a comparator: current premium daily wear devices. It was hypothesized that the extended wear devices may offer greater psycho-social benefit than daily wear due to the 24/7 wearing time and anecdotal evidence that Lyric users often reported feeling more "normal".

Design: A within subjects cross over design was used in this study. Initially, 23 participants were recruited from the PARC database and from a private clinic. Seventeen completed the study. All participants were new to amplification and Lyric candidates. Each participant completed several outcome measure questionnaires in the unaided condition. These questionnaires included the Listening Self Efficacy Questionnaire (LSEQ), Hearing Handicap Inventory for Adults (HHIA), and Expected Consequences of Hearing Aid Ownership (ECHO), as well as the Big Five Index (BFI), Fear of Aging, and the Functional Social Support Questionnaire (FSSQ). Participants were randomly assigned to start with either the Audeo B90-R devices or the extend wear Lyric devices. Participants wore devices for four weeks and completed outcome measures for the aided condition. These measures included the LSEQ, HHIA, Satisfaction with Amplification in Daily Living (SADL) and the PyschoSocial Impact of Assistive Devices (PIADS). They were then fit with the second set of devices and wore for four weeks. At the end of the second trial, participants completed a second set of the same aided outcome

measures. Statistical analysis included ANOVA and post-hoc follow up testing between the three conditions, as well as between the unaided and overall aided condition.

Results: There were no significant differences between the two devices. The PIADS revealed a significant positive impact with the use of either device. There were significant differences between the ECHO and SADL for both types of devices as well. The LSEQ results showed that particpants' confidence in their ability to hear significantly increased with use of hearing devices.

Conclusions: In recent years, much attention has been directed to the co-morbidities of hearing loss, such as depression and cognitive decline. Clinicians are recognizing the importance hearing has on overall health. The results of this study validate that amplification, whether daily wear or extended wear, can significantly influence patients' psychosocial and emotional well-being by increasing their confidence in their ability to hear in complex situations and by positively impacting their perceptions of self esteem, competence, and adaptability.

Poster # 159

Does Audiologic Intervention Improve Satisfaction with Direct-to-Consumer Hearing Aids?

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Objectives: Direct-to-consumer hearing aids are intended to improve access to affordable hearing devices for individuals with hearing loss. Although this dispensing model might result in better access to more affordable hearing devices, there is some concern that, without accompanying audiologic services, direct-to-consumer hearing aid users will have poorer satisfaction with their devices and, ultimately, will discontinue further attempts to improve their hearing health. This research compared patients' satisfaction when direct-to-consumer hearing aids were provided using a traditional audiological model and a self-fitting model of care.

Design: Twenty-three adults with bilateral sensorineural hearing loss and no previous experience with hearing aids participated in this double-blinded randomized control trial. Each participant was provided bilateral direct-to-consumer devices and randomized into one of two groups. The experimental group received audiologic services including a comprehensive orientation and recommended volume and program settings based on real-ear verification. The control group received the direct-to-consumer hearing devices but no further audiologic services were provided. Data were collected over two visits separated by a one-week trial with the devices. Self-reported satisfaction with the devices in daily listening was assessed using the Satisfaction with Amplification in Daily Living (SADL) questionnaire after the trial.

Results: The 15-item SADL divides content into 4 areas of satisfaction with amplification in daily listening: Positive Effect, Personal Image, Service and Cost, and Negative Features. When comparing averaged subscale scores to existing norms, preliminary analyses revealed satisfaction with the direct-to-consumer devices that was similar to or better than the original normative data (i.e., collected from individuals fitted with 1990s era hearing aids.) No significant differences in subscale scores were observed for participants in the experimental and the control groups. However, comparisons of individual item scores suggest a possible clinically important positive impact of audiologic intervention on some elements of hearing aid satisfaction. Perhaps unsurprisingly, responses to items related to satisfaction with the acoustic benefits and reliability of the devices were not different between the two groups. However, audiologic intervention had moderate to large positive impacts on satisfaction related to amplified background noise, cosmetics, and perception of audiologic services and small positive impacts on satisfaction with sound quality and hearing aid stigma.

Conclusions: Direct-to-consumer hearing aids are limited in the amount of individualized adjustments that can be accomplished by a hearing health care professional. This research demonstrated that adults with uncomplicated age-related hearing loss are likely to report satisfaction with direct-to-consumer hearing aids and receive similar levels of satisfaction with the acoustic benefits of these devices regardless of how they are delivered (i.e., with or without additional audiologic services.) However, there is some suggestion that audiologic services can provide hearing aid users with improved satisfaction related to aspects of hearing aid performance in daily life, psychological effects of hearing aid use, and perceptions of hearing aid services.

Poster # 160

Hearing Aid Outcomes in Patients with Posttraumatic Stress Disorder

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Objectives: The purpose of this study was to compare hearing difficulties and hearing aid outcomes in veterans with Posttraumatic Stress Disorder (PTSD) to a group of veterans with no medical diagnosis of PTSD. Our hypothesis was that veterans with PTSD would have poorer hearing aid outcomes in certain domains (e.g., those related to loudness or interactions with the environment) relative to patients without PTSD. Assessing these differences could help identify unique factors that may lead to the development of tailored aural rehabilitation for hearing aid users with PTSD.

Design: This descriptive study employed subjective outcome measures and surveys; the Abbreviated Profile for Hearing Aid Benefit (APHAB) served as the primary outcome measure. An additional questionnaire was developed to assess views of the subjects' hearing in unaided and aided conditions in an effort to explore the relation between hearing aid benefit and PTSD symptoms. A total of 60 veterans with sensorineural hearing loss and bilateral hearing aid use were recruited from the Audiology Clinic at the James H. Quillen Veterans Affairs Medical Center in Mountain Home, TN. Participants were divided into two groups of subjects either with or without PTSD (n=30 in each). Diagnosis of PTSD was confirmed via a chart review of the veteran's medical record.

Results: Results from the APHAB revealed a significant difference between groups in global benefit scores as well as the aversiveness subscale in the unaided condition. Overall, the PTSD group showed lower benefit scores, however outcomes indicated that both groups received benefit when aided. Results from the study questionnaire showed a significant difference between the two groups in both unaided and aided conditions for the questions focused on hyper-arousal and re-experiencing symptoms.

Conclusions: Hearing aid users with PTSD perceive less benefit from hearing aid use on traditional hearing aid outcome measures. Additionally, these hearing aid users were more affected by hyper-arousal, re-experiencing symptoms, and avoidance compared to hearing aid users without PTSD. The clinical implications of this work suggest that hearing aid users with PTSD may need modified hearing aid fittings and/or additional counseling to meet their unique listening needs.

Poster # 161

The Use of a Remote Control Application with Pre-Teen and Teenage Hearing Aid Users

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Objectives: The primary objective of this study was to evaluate preference and performance implications of fine-tuning changes made with a hearing aid remote control application in the teenage and pre-teenage population.

Design: Eighteen children (10 to 17 years old; mean age =13 years old [standard deviation = 1.9]) with sensorineural, mild/moderate-to-moderate-severe hearing loss participated in this study. All participants had used binaural hearing aids for at least two years.Each of the study participants was fitted with either the Bolero M-PR or Audeo M90-R hearing aids. Bolero M-PR was used, since Sky Marvel hearing aids were not compatible with the remote control application at the time this study was completed. The Bolero Marvel hearing aid is the same form factor and provides the same output levels as the Sky Marvel device. Behind-the-ear or receiver-in-canal form factor was chosen based on each child's hearing loss. These hearing aids were coupled to custom c-shells or earmolds that were acoustically optimized, per the child's hearing loss. The study was a total of two total study visits, with a one-week home trial between. At the first study visit, hearing aids were programmed to provide an output that matched the Desired Sensation Level version 5.0 (DSL 5.0) pediatric targets (+/- 5 dB) at 250, 500, 1000, 2000, 4000, and 6000 Hz for the Audioscan Verifit Standard Speech signal presented at 55, 65, and 75 dB SPL. These thresholds were verified with probe microphone measurements. Participants were oriented to the MyPhonak Remote Control application and received a "modifier training," during which the participants were asked to describe any audible changes as the modifier sliders were manipulated by the experimenter. This training was done to ensure each participant could hear changes made via the Remote Control application, and learn the degree and types of changes possible in the application. A baseline LSEQ (Listening Self Efficacy Questionnaire) was completed at this initial visit.Each participant took the hearing aids and the Remote Control application home for one week. Participants were encouraged to use the application in their home and school environments, and feedback about this home trial was collected at the final study visit. Participants also completed subjective and objective, side-by-side comparisons between the automatic hearing aid program and lab-created custom programs using the Remote Control app in a variety of listening scenes. These comparisons were done to determine the effect of application changes on audibility and preference.

Results: Teens and pre-teens were able to use and navigate the Remote Control application. The remote control fine-tuning changes made in the custom, lab-created programs consistently reflected a reduction of gain in the high frequencies, and negatively impacted performance on a speech-in-noise task as compared to performance in the automatic hearing aid program.Despite this objective result, the result of subjective testing indicated a strong, positive preference for the custom programs created with the remote control application as compared to the automatic program. An additional advantage that emerged was an increase in the number of hours of use time with the laboratory hearing aids and the remote control application during the home trial, as compared to baseline datalogging measures with participants' personal hearing aids. Results on the LSEQ indicated a significant increase in perceived self-efficacy with lab hearing aids and the remote control application as compared to personal hearing aids in complex listening environments.

Conclusions: The results of this study indicate significant subjective and objective implications for increased control via a remote control application in the teenage and pre-teenage population. Additional safeguards are needed to ensure audibility is not negatively-impacted by changes made in the application. Once these safeguards are put in place, this study suggests significant benefit in the psychosocial domain and increased wear time with the availability of remote control application in this population.

Poster # 162

Using App-based Ecological Momentary Assessment to Evaluate Social/Emotional Well-being
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Objectives: A study using app-based ecological momentary assessment investigated the effects of hearing loss on emotional recognition.

Design: Twenty participants were given a mobile ecological assessment application for a one week home trial. The app was designed to prompt the participant to answer surveys related to their current listening environment and their emotional response to it. Ten participants were experienced hearing aid users and ten participants had normal hearing/unaided mild hearing loss. Each participant was given a pair of hearing aids to wear; however, only the experienced hearing aid users received amplification. The hearing aids were paired to the app and were used to gather information about the listening environment. This information was used to trigger the app surveys in addition to time-randomized prompts.

Results: Results indicate there is a difference in the amount of social activity between the hearing impaired and normal hearing groups. Participants in the normal hearing group reported being in more complex social environments than the hearing impaired participants. The frequency of which they were in these environments was also greater.

Conclusions: The study findings provide supporting evidence that hearing loss can decrease social activity, either by the type of social gathering (simple or complex) or the frequency of participation. Future research is planned to further investigate this effect and the connection of hearing loss to social/emotional well-being.

Poster # 163

Can the Average Consumer Navigate Over-The-Counter Hearing Aids?
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Objectives: The Over-The-Counter (OTC) Hearing Aid Act was introduced in an effort to make hearing aids (HA) more accessible and affordable. Implementation of this law will go into effect in 2020. It is assumed that the average consumer will be able to self-navigate an OTC HA fitting, but limited research has investigated this assumption. In the OTC HA fitting model consumers are required to self-detect the presence of a hearing loss, rule out the presence of ear disease, self-select a device that they feel is most appropriate for their listening needs, and then set up the device on their own. The purpose of the present study was to assess how well the average consumer can perform each step in the OTC HA fitting Model.

Design: Although OTC HAs are not currently available, there are direct-to-consumer (DTC) HAs available online. Self-selection and fitting of DTC devices is similar to self-navigating and fitting an OTC HA. Participants included 45 adults who were 40 years of age and older, self- reported having trouble hearing, were interested in trying a DTC-HA, owned a smartphone and had no prior HA experience. Data was collected over two tests sessions. During the first session all participants were asked to report their degree of hearing loss, identify if they think they are at risk for having ear disease, and complete questionnaires related to demographics, health literacy, HA self-efficacy, health locus of control, and technology commitment and usage.

Also, participants were given a hearing test and administered three cognitive measures: the Reading-SPAN, Digit Symbol Substitution Task, and the Simon task. During the second test session participants were asked to browse three different DTC-HAs online and select the device they preferred. They were also asked to complete a questionnaire of potential reasons for why they selected a particular device. They were provided the DTC-HA they selected in its original packaging, and then asked to set it up without any assistance. The Practical Hearing Aid Skills Test- Revised (PHAST-R) along with three questions related to Bluetooth connectivity was used to evaluate the participants' HA use skills. Real-ear verification was performed to assess how closely the participant's settings were to NAL-NL2 targets. Last, participants completed the Consumer Ear Disease Risk Assessment (CEDRA).

Results: Preliminary results found that the majority of participants could not correctly classify their degree of hearing loss, and/or overlooked the presence of their risk for ear disease as indicated by the CEDRA. Participants scores ranged from 45-90% on the PHAST-R and Bluetooth connectivity assessment, which suggests many consumers will likely purchase OTC hearing aids that they will not be able use properly. Differences between participants' self-fit gain and prescribed target gains were observed and varied across the three DTC-HAs. Participants reported that their HA selection was based on clear website descriptions and price.

Conclusions: Most participants, who were average consumers, were unable to successfully self-navigate all of the steps in the OTC HA fitting Model. Several factors influenced participants' ability to successfully self-navigate fitting the DTC hearing aids.

Poster # 164

Increase in SSQ-12 Ratings for Both New and Experienced Users

Nikolai Bisgaard, MS; Tobias Piechowiack, PhD, GN Hearing, Ballerup, Denmark

Objectives: Investigating the change in SSQ-12 survey results for new and experienced users before and after fitting.

Design: As part of a large scale project to improve clinical guidelines in Denmark a large cohort of primarily elderly people with hearing loss were invited to participate in the project. 30 % were experienced users and 70 % new users. The subjects submitted SSQ-12 and 15-D prior to their first visit where an audiological assessment was made. At the second visit hearing aids were fitted. 3 months later the same set of questionnaires were sent prior to the third visit. At the third visit Real Ear measurements were made to document the fitting. If fine-tuning of the fitting was required it was performed and new measurements made. Approximately 600 patients were fitted with two different line of hearing aids from GN Resound and the appropriate form factor for each patient selected. The outcomes are expressed in two ways: The change in the 15-D QoL results and the change in SSQ-12 results. Furthermore, the use time per day was assessed both subjectively and by means of the data logging function in the hearing aids.

Results: Overall, the data shows that on average both participant group experienced some increase in QoL and an improvement in hearing ability as expressed by SSQ-12. The gain was higher for new users. The use time varied a lot across participants and the accuracy of the self-assessment was quite good.The total group can be split in several subgroups according to the outcomes and various objective parameters and this analysis will be presented.

Conclusions: Both new and experienced users benefit from new hearing aids.

Poster # 165

Model for Estimating Hearing Aid Uptake Across the World

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Objectives: How can hearing aid uptake be estimated in countries with little available data?

Design: Prevalence of hearing loss is well established in many countries. The scientific literature on this topic is abundant and the consensus is that up to 25 % of the population in most countries have some degree of hearing loss. WHO states that 5 % of the population suffers from a disabling hearing loss. It is also well known that the coverage with hearing aids vary considerably from country to country although very little solid information on this topic exists. The differences can arise from economic, cultural or other factors.

Results: Data on unit sales is being monitored and published in a number of countries and for countries without public data, reasonably accurate estimates can be made, but that is still only part of the answer. Factors like bilateral fitting frequency and hearing aid replacement patterns are important to know in order to translate unit sales to coverage. Since 2009, Eurotrak surveys have been conducted in many different countries around the world and have been repeated regularly in certain countries. The EuroTrak surveys provide estimates of coverage for each country and using data from these countries, a model linking hearing aid unit sales to coverage has been developed.

Conclusions: Using this model the hearing aid coverage can be estimated for any country with a reliable estimate of unit sales. The results show a clear connection between GDI and hearing aid coverage. The highest coverage rates are found in Northwestern Europe and Australia, whereas coverage rates in other high-income countries are much lower.

Poster # 166

Factors Affecting Hearing Aid Adoption: The Beaver Dam Offspring Study

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Objectives: Most people who could benefit from hearing aids do not adopt them and reasons for this are often complex and not well understood. High frequency hearing loss (HFHL) is known to affect clarity and distinction of speech, particularly in the presence of background noise. HFHL is also considered to be clinically

aid-able in the literature. In this study, we investigated factors associated with 10-year cumulative incidence of hearing aid adoption in middle-aged to older adults.

Design: The Beaver Dam Offspring Study (BOSS) is a longitudinal cohort study (2005-2018) examining aging and sensory disorders in adults (n=3298, age range=21-84 years). Hearing thresholds (0.5-8.0 kHz), hearing aid adoption, and additional covariates were measured at baseline, 5- and 10-year follow-up periods. We calculated pure-tone averages (PTA) for high frequencies (3, 4, 6, 8 kHz) and defined a HFHL as PTA > 25 dB HL in the better ear. Hearing aid adoption was defined by a "yes" response to the survey question, "Have you ever worn a hearing aid or amplifying device?" at either the 5- or 10-year follow-up period. Covariates were obtained from a questionnaire. Associations between hearing aid adoption and covariates were estimated using multivariable Cox discrete-time proportional hazards models. Associations are presented as hazard ratios (HR) and analogous 95% confidence intervals (CI).

Results: There were 579 participants with HFHL (mean age: 57.8 years, range: 34-80) and 69 participants (11.9%) adopted hearing aids. In a sex-adjusted model, hearing aid adoption was significantly associated with age, per one year increase (HR: 1.03, CI: 1.00, 1.06). In age-sex adjusted models, participants were significantly more likely to adopt a hearing aid if they reported bothersome tinnitus (HR: 2.43, CI: 1.43, 4.13), had a higher score on the hearing handicap inventory for adults/elderly-screener (HHIA/E-S) (HR: 1.08, CI: 1.05, 1.10), had self-reported hearing loss (HR: 4.68, CI: 1.99, 11.01), answered "yes" to the question, "Do friends and relatives think you have a hearing problem?" (HR: 5.72, CI, 3.14, 10.43), had difficulty understanding when multiple people are talking (HR: 9.02, CI: 2.18, 37.25), reported difficulty following a quiet conversation with a doctor (HR: 2.11, CI: 1.03, 4.31), reported sometimes having difficulty talking on the telephone (HR: 2.14, CI: 1.22, 3.76) or used closed captions on their television (HR: 4.66, CI: 1.891, 11.48). In a multivariable model, age (HR: 1.04, CI: 1.01,1.07), HHIA/E-S score (HR: 1.04, CI:1.01, 1.07), reported perception of friends and relatives (HR: 3.84, CI: 1.93, 7.61), and using closed captions (HR: 3.15, CI: 1.21, 8.23) were significantly associated with hearing aid adoption.

Conclusions: In a multivariable model, adults with HFHL were more likely to adopt a hearing aid if they were older, had higher scores on the HHIE/A-S, stated that their friends or relatives think they have a hearing loss, and used closed captions. These findings could indicate self-perception and social factors are important for hearing aid uptake. This has important implications for issues to address during hearing aid evaluation appointments.

Poster # 167

Willingness to Pay for Hearing Aids, Over-the-Counter Devices, and Services

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Objectives: Accessibility to and affordability of quality hearing health care (HHC) have become a concern of providers, policy makers, and patients over the last decade. Health care (HC) economics has scarcely been

applied to the HHC industry in the United States. For example, little is known about patients' willingness to pay (WTP) for advanced digital technology (ADT) hearing aids (HAs), over-the-counter (OTC) devices, and related services. WTP is a cost-benefit analysis (CBA) in which consumers assign monetary values as an index of preference for theoretical or actual goods or services. To date, no studies have assessed WTP for ADT hearing aids, OTC devices, and related services among a non-veteran American population. Our hypotheses were that benefit-cost ratios would be highest for ADT hearing aids and lowest for OTC devices, and that WTP would be associated with all patient-related variables.

Design: A cross-sectional postal survey of experienced amplification users from two private practices obtained WTP for ADT HAs, related services, and OTC devices using open-ended (i.e., fill in the blank) and payment-scale (i.e., choose one) questions. CBAs were conducted for ADT HAs, OTC devices, and related services among current users of amplification. Associations between WTP and patient-related variables (i.e., HA benefit, unaided hearing difficulty in noise, annual income, importance of hearing, and satisfaction with services) were studied using logistic and ordinal regression analyses to determine perceived value of devices and services. All models controlled for study site.

Results: 70 surveys were completed, representing a 15.6% response rate. WTP for an ADT HA was correlated with actual out-of-pocket (OOP) expense ($r = 0.4$, $p = 0.01$), suggesting good validity of the open-ended WTP question. Open-ended WTP for one ADT HA was $1,830. Similar results were found for the ADT payment-scale question. WTP for an OTC device was lower, with most (64%) indicating a WTP of $0 (not willing to pay). WTP for related services was most commonly $250 (29%) or $100 (20%). Benefit-cost ratios indicated a net positive benefit for ADT hearing aids at the average OOP cost, for related services at $250, and for OTC devices at $50. Income was the only variable significantly associated with WTP for ADT HAs, where higher earners were willing to pay more than those with lower incomes. No associations were identified between patient-related factors and WTP for related services or OTC devices.

Conclusions: Average WTP ($1,830) was lower than average overall costs for one ADT HA. Experienced wearers indicated positive net benefits for ADT hearing aids and related services. WTP and benefit-cost ratios for OTC devices did not result in a positive net benefit until costs were low ($50). These results provide much needed information on perceived value in a changing HHC marketplace. Income was a significant determinant of WTP indicating that cost conversations should occur as part of the HA selection process. Information on consumers' WTP may assist the HHC industry to set prices according to what seems reasonable to individuals who would benefit most from amplification.

Poster # 168

A Pilot Assessment of e-Audiology for Hearing Aid Follow-up Appointments

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Objectives: Large-scale studies are needed to determine the efficacy of telehealth audiology applications ("e-Audiology") on hearing outcomes. The purpose of this pilot was to provide insight for the process, feasibility, and outcomes of remote e-Audiology services to guide protocols for a future multi-site study. With regard to audiological outcomes, we hypothesized that subjective hearing difficulties would improve and that measured real-ear aided responses (REARs) would be consistent from baseline to 6-week follow-up. We additionally hypothesized that patient satisfaction and comfort with technology would be high following the intervention period.

Design: A convenience sample of 10 first-time hearing aid users over the age of 70 were sampled from a clinical population. Inclusion criteria were access to a smartphone, stable internet connection, at least a mild hearing loss in the better ear, and normal cognition and corrected vision. Individuals were excluded if they presented with a bilateral conductive hearing loss or reported that they would not be willing to use hearing aids at least 4 hours/day throughout the study duration. All participants were initially fit within 3-dB of NAL-NL2 prescriptive targets between 250-8000Hz in-office with Phonak Audeo M-90 312T hearing aids. Two remote sessions were completed using the myPhonak app after the initial fitting. Subjective measures included the Hearing Handicap Inventory for the Elderly (HHIE), Speech, Spatial, and Qualities of Hearing Questionnaire (SSQ), Visit Specific Questionnaire (VSQ-9), and the Telehealth Acceptance Questionnaire (TAQ). Objective measures included unaided and aided real ear responses and Quick Speech-in-Noise (QuickSIN) testing. Both subjective and objective measures were evaluated at the time of the hearing aid fitting and after a 6-week follow-up period.

Results: Wilcoxon signed-ranked tests were performed to determine if the baseline and 6-week follow-up results differed for the QuickSIN, HHIE, TAQ, and REARs. Baseline scores significantly improved after 6-weeks (ps=.02, .005, and .005 for the QuickSIN, HHIE and TAQ, respectively). Participants had better speech in noise performance in the aided condition and reported fewer self-perceived hearing and technology difficulties at the follow-up. REARs from 500-4000Hz measured after 6-weeks did not differ from baseline REARs (ps=0.612, 0.398 for the right and left ears, respectively) suggesting no significant deviation from prescriptive targets as a result of remote fitting adjustments. SSQ outcomes revealed improvement at the 6-week follow-up in each of the 3 domains. Participants additionally reported improvement in COSI goals throughout the 6-weeks. Results from subjective and objective outcomes were largely consistent with our hypotheses. However, while all participants were provided the same hearing aids and myPhonak orientation, there were varying experiences in terms of WiFi stability and comfort with using the app.

Conclusions: Assuring there is a stable internet connection, providing take-home self-management materials and properly orienting the participant to the care and maintenance of hearing aids along with the myPhonak app while they are in-office are essential elements to the success of an e-Audiology service model. Our results enhance the evidence-base for the implementation of e-Audiology in a future large-scale observational study.

Poster # 169

Plasticity Changes Following a Short Remote Microphone System Training
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Objectives: The purpose of this study was to investigate whether a short speech-in-noise training with a remote microphone system (RMS) induced changes in cortical auditory evoked potentials (CAEPs) of children with normal hearing. We hypothesized that larger amplitudes and shorter latencies would be observed in CAEP

components in response to speech in noise after the RMS training but not after the same training received by a control group who did not use the RMS.

Design: Fifty children between the ages of 9 and 12 years with typical development and normal hearing will be enrolled in this study (the data from 35 participants have been collected at the time of this writing). Children's CAEPs are recorded while actively listening and discriminating between two different speech syllables ([da] and [ga]). CAEPs are collected in four different conditions. In the first condition, children listen to speech syllables in quiet (quiet condition). In the second condition, children listen to the same speech stimuli in the presence of background noise at +5dB signal-to-noise ratio (SNR; baseline condition). No feedback is provided to the children in these two conditions. The third CAEP condition is considered the training portion of the study. For this training condition, participants are divided into two groups of 25 participants. The two groups receive a 10-minute speech-in-noise active training, in which they listen to the same stimuli as in the baseline condition. Feedback (correct or incorrect) is provided. One of the groups (RMS group) uses the RMS programmed at +10dB mix ratio during training. As a result, speech syllables are delivered to the participants in this group at +15dB SNR. The other group (no-RMS group) is trained without the RMS. Thus, they receive training at +5dB SNR. The no-RMS group serves as a control to ensure that potential CAEP changes are not simply related to stimulus familiarity. For the fourth condition of the study (post- training condition), both groups listen to the speech stimuli at +5dB SNR with no feedback (same as baseline condition). CAEP responses are compared for both groups between the baseline and post- training conditions.

Results: Preliminary analyses suggest that, as hypothesized, children in the RMS group have significantly larger amplitudes and shorter latencies in P1 and P2 CAEP components in the post- training condition compared to the baseline condition. This suggests greater neural synchrony post-training after the RMS training for early speech identification responses (P1) and also attentional/selection processes (P2). To date, no pre-post training differences have been observed in the CAEPs of the no-RMS group.

Conclusions: If our preliminary findings are confirmed with the larger sample, results would suggest that listening to an increased SNR via an RMS induces plasticity changes, at least in the short term, at the cortical level in children. These findings would support growing clinical evidence that recommend extending RMS use in children with hearing difficulties beyond the classroom setting (e.g., the home environment).

Poster # 170

Non-Customized Gain-Frequency Responses for Preconfigured Hearing Aids: A Clinical Trial

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Objectives: Nearly two-thirds of older Americans have hearing loss (HL). If untreated, this could lead to communication difficulties, anxiety, social isolation, and possibly, dementia. Though hearing aid amplification is the primary management option for age-related HL, few older Americans with HL (~30%) use hearing aids. Most of individuals with hearing loss (>75%) cite financial barriers to the adoption of hearing aids. To improve affordability and access to hearing health care, Congress passed the Over-the-counter (OTC) hearing aid act in 2017. This act requires the FDA to develop a new category of hearing aids called OTC hearing aids for older individuals with mild to moderate HL. Many current OTC hearing aids do not provide adequate audibility for age-related mild to moderate HL because of their inappropriate frequency response. To overcome this limitation, researchers in our lab developed new gain frequency responses using audiometric data from a large

epidemiological database. The aim of the current study was to evaluate the efficacy and effectiveness of the presets developed (the "HAAR" condition) in the laboratory and real world compared to traditional audiologist-fit hearing aids (the "AUD" condition) and an existing OTC hearing aid (the "OTC" condition). We hypothesized that the outcomes of the HAAR condition will be comparable to the AUD condition and will be better than the OTC condition.

Design: Thirty-seven older adults (18 females, mean= 70.5; range= 55-85 years) with bilateral mild-to-moderate sensorineural HL participated in this single-blinded randomized cross-over clinical trial. We tested the outcome domains of audibility, speech recognition, listening effort and sound quality using laboratory testing, and questionnaires to estimate real-world performance. We also asked participants for their subjective preference among the three hearing aid conditions.

Results: Linear-mixed-models and follow-up testing with Tukey with correction for multiple comparisons was used to compare outcomes in the laboratory and in real-world in all conditions. We found that scores in AUD condition were significantly better than OTC condition in most domains measured. The scores for HAAR condition were significantly better than the unaided condition. Moreover, HAAR was also significantly better than the OTC condition for the audibility ($p=0.020$) and the speech recognition ($p=0.038$) domains in the real-world. We compared subjective preferences of participants using the Cochran's Q-test and conducted follow-up testing by Dunn test. Twenty out of thirty-seven participants preferred HAAR to OTC hearing aids ($p=0.007$), and there was no significant difference between preferences for HAAR and AUD hearing aids ($p=0.134$).

Conclusions: We expected the AUD hearing aids to have good outcomes because these hearing aids were set using Audiology best-practices. However, that the HAAR scores were better than OTC hearing aids in audibility and speech recognition domains in the real-world, and majority of the participants preferred HAAR hearing aids over the other hearing aid configurations shows that the gain frequency responses developed by our lab are effective for individuals with age-related mild to moderate HL. The study suggests that using self-selection to choose appropriately-designed preconfigured hearing aids followed by minimal audiology services may work for older adults seeking more affordable hearing aids and services.

Poster # 171

Portable Hearing Laboratory: Nice Finish, But is this Only the Beginning?

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Objectives: The first objective is introduce to you or refresh your knowledge on the what exactly is the Portable Hearing Laboratory, or PHL? Who and why wanted to make it? Some of the big movers at the time to have this done will be in the audience so we may get a little discussion there.

Design: Then we will go through its design, and hands on (well eyes on) demos. The Portable Hearing Laboratory (PHL) features a central unit (BatAndCat Box) which provides an appropriate hearing aid ambient for either a new algorithm development or for clinicians to perform real life studies, with realistic delivery systems, on clinical issues. It is just like a hearing aid but the one you can manipulate at will

Results: After several years of development the Portable Hearing Laboratory is actually beginning to be used not as an object of research, but the other way round as a tool for doing research. That makes us all very proud and also very thankful to NIDCD for spearheading this work. In this talk we will first present the device as it is now and then discuss how you can use it, and even more to the point how you would like to use it. .

Conclusions: We hope that we can then move this discussion to the evening party with lots of noise and lots of ideas.

SPEECH PERCEPTION

Poster # 172

Differences Between the Perception and Production of Sung Melodies
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Objectives: Individuals constantly use their perception of their vocal production to increase the stability and accuracy of that production. However, this ability to use perception to guide production may be tightly tied to physiological connections between the auditory system and the motor system. The goal of this study is to determine whether this ability to use perception to guide production extends to modifying productions that do not involve the individual's own vocal tract.

Design: Five young normal hearing listeners recreated "Happy Birthday" twice, once with a series of recordings of a male voice singing /a/ and once with a series of recording of a female voice singing /a/. They also listened to and judged 10 samples of "Happy Birthday" previously created with the same task by individuals with single sided deafness and a cochlear implant using the recorded male voice. The samples were chosen to represent a range of accuracy. The normal hearing listeners rated the "Happy Birthday" re-creations on a scale of 1 (completely inaccurate), to 10 (completely accurate).

Results: The results indicate that, while there was considerable agreement across participants in terms of their judgment of what was an accurate version of the song, the melodies produced by the participants were often highly inaccurate.

Conclusions: The results suggest that normal hearing listeners have difficulty using perception to guide productions that do not involve their own voice.

Poster # 173

Cochlear Implants Change Memory Demands in Speech Recognition
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Objectives: Speech recognition is associated with tests of working memory (e.g. reading span) in listeners with cochlear implants, but not in listeners with normal hearing. One reason for this difference across groups of listeners could be differences in the auditory cues conveyed by electric and acoustic hearing. In our previous work, we used vocoded speech to approximate the auditory cues conveyed by cochlear implants. We found that

vocoded speech recognition in listeners with normal hearing was correlated with tests of short-term memory (e.g. digit span). The goal of this project was to determine if a similar correlation between short-term memory and speech recognition was also present in listeners with cochlear implants.

Design: Seventeen post-lingually deafened adults with cochlear implants participated in this study. Individual speech recognition ability was assessed with PRESTO sentences. To control for the known effects of spectral and temporal resolution on speech recognition, listeners completed spectral and temporal modulation detection tasks. Short-term memory was assessed with an auditory forward digit span task.

Results: The distribution of short-term memory performance across listeners was similar to that of listeners with normal hearing. Short-term memory performance was not associated with individual differences in auditory resolution. Individual differences in speech recognition were predicted by spectral and temporal resolution, which were independent of one another. After factoring out the effect of spectral and temporal resolution, no relationship between short-term memory performance and speech recognition was found.

Conclusions: Speech recognition is associated with working memory but not short-term memory in listeners with cochlear implants. This result which is the converse of the relationship found in young adults with normal hearing. This difference is not due to changes in memory ability across groups of listeners, so instead it is likely to arise from differences in auditory input across groups.

Poster # 174

Does Neurocognitive Functioning Impact Degraded Sentence Recognition?

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Objectives: There is a large body of evidence to suggest that neurocognitive skills play a role in successful speech recognition for adult cochlear implant users, yet the underpinnings of these relationships remain unclear. However, recent models theorize that neurocognitive resources are allocated differently depending on task demands, which can be affected by internal (e.g., an impaired auditory system) and external (e.g., background noise) factors. No current research study has explored the relationship between neurocognitive skills and sentence recognition across multiple degrees of spectral degradation. Therefore, the first objective of the present study was to determine if the degree of spectral degradation is associated with the degree to which neurocognitive resources play a role. It was predicted that when task demand is too high or too low, participants will not engage higher neurocognitive processes, and thus performance on neurocognitive tasks will only correlate with performance on moderately degraded sentences. The second objective of this study was to determine how audiovisual presentation of speech materials would affect the relationship between degraded speech recognition and neurocognitive performance.

Design: Twenty-four normal-hearing undergraduate students were recruited for the present study. Inclusion criteria included normal pure-tone thresholds, near vision of 20/40 or better, and being a native English speaker. Participants were presented with 60 sentences from the Multimodal Lexical Sentence Test for Adults. The 60 sentences were blocked into three spectral degradation conditions: no degradation (clear sentences); moderate degradation (8-channel noise-vocoded); and high degradation (4-channel vocoded). Thirty sentences were presented in an auditory-only modality, and 30 were presented on a screen in combined audiovisual fashion with lipreading cues present. Assessments from the National Institute of Health (NIH) Toolbox's Cognitive

Battery were also completed to evaluate working memory, inhibition-concentration, attention shift skills, and processing speed.

Results: As expected, results revealed a main effect on sentence recognition of degree of degradation (clear vs 8-channel vs 4-channel vocoded) and a main effect of modality (auditory-only vs audiovisual). No correlations between the auditory-only conditions and the neurocognitive scores were observed. However, inhibition-concentration skills were significantly correlated with sentence recognition in the moderately degraded audiovisual condition. Additionally, processing speed was significantly correlated with the magnitude of audiovisual benefit when comparing audiovisual scores versus auditory-only scores of sentence recognition.

Conclusions: The findings of this study suggest that inhibition-concentration skills and processing speed may play important roles in successful speech recognition for listeners who receive degraded signals (e.g., hearing aid users and cochlear implant recipients). Moreover, these results support the growing body of multisensory processing literature suggesting that neurocognitive skills may come into play more during complex sensory conditions. Results of this study also suggest the importance of testing hearing-impaired listeners in audiovisual conditions that resemble real-world environments in order to better understand the role of neurocognitive processes needed for successful speech recognition.

Poster # 175

Factors Affecting Speech-in-Speech Recognition in Preschoolers

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Objectives: The goals of the present study were to 1) characterize the speech-in-speech recognition abilities of preschool children and 2) evaluate the influence of age and receptive vocabulary on individual differences in preschool-age children's speech-in-speech recognition performance. Two hypotheses were formed based on previous research concerning developmental effects and receptive vocabulary: 1) speech-in-speech recognition improves with increasing age across the preschool period and 2) preschool children with larger receptive vocabularies have better speech-in-speech recognition abilities than children with smaller receptive vocabularies.

Design: Participants were 22 children (3.0-4.9 years) and 10 adults (20-30 years); all participants had normal hearing. Stimuli consisted of two sets of disyllabic words: 1) a set of 30 words with an average age of acquisition ranging from 2.37-6.78 years and 2) a set of 8 words with an average age of acquisition ranging from 2.37-3.61 years. Recordings from three different female talkers were used for the target and two masker stimuli, respectively. Speech reception thresholds (SRT) were measured under supra-aural headphones using an adaptive, four-alternative forced-choice picture-pointing procedure. The masker remained fixed at 55 dB SPL and the target signal was adapted using a two-down, one-up procedure to estimate threshold equivalent to 71% correct. Receptive vocabulary was assessed via the Receptive One-Word Picture Vocabulary Test (ROW PVT) in a quiet room.

Results: The results of this study indicate that SRT improves with increasing age for preschool children for the set of 30 target words ($r = -0.68$, $p < 0.001$) and the set of 8 target words ($r = -0.67$, $p < 0.001$), with preschoolers requiring approximately 11 dB greater signal-to-noise ratio than adults to obtain similar performance for

speech-in-speech recognition for both target sets. Linear mixed modeling for the set of 30 words revealed significant effects of receptive vocabulary and age on SRT ($p = 0.009$ and $p = 0.02$, respectively). Specifically, for each 10-point increase in receptive vocabulary, SRT decreased by 1.9 dB; for each year of child age, SRT decreased by 1.6 dB. The interaction between age and receptive vocabulary was also significant ($p = 0.038$), indicating that there is a decreasing effect of receptive vocabulary size on SRT with increasing child age. Linear mixed modeling for the set of 8 words revealed significant effects of age on SRT ($p = 0.005$); for each year of child age, SRT decreased by 3.2 dB. However, the effect of receptive vocabulary on SRT was not significant when age was taken into account ($p = 0.71$).

Conclusions: Preschool-age children require an 11 dB higher signal-to-noise ratio than adults to achieve 71% correct word recognition in a two-talker masker. Developmental effects are seen even within the preschool period, with younger preschoolers requiring a higher signal-to-noise ratio than older preschoolers. Receptive vocabulary size may play a larger role in performance for corpora with a higher average age of acquisition than those with a lower average of acquisition. The results from this study illustrate a developmental trajectory for speech-in-speech recognition within the preschool period.

Poster # 176

Cochlear Contributions to Differences in Cocktail-Party Listening

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Objectives: Cocktail-party listening (CPL)' refers to everyday listening situations where multiple sounds compete for our attention. There is large variation across individuals in the ability to listen effectively in such environments, even among those with clinically normal hearing. Lutfi et al. (2018) sought to gain a greater understanding of these individual differences using a simulated CPL experiment where spectral and spatial cues varied. The weighting efficiency - an individual's ability to use the cues available - and internal noise - other factors affecting the response that are unrelated to the signal - were estimated using a perturbation analysis (Berg, 1990). Individual differences in performance were mainly due to internal noise. But the source of the internal noise is yet unknown. The present study explores cochlear contributions to internal noise by measuring stimulus frequency otoacoustic emissions (SFOAEs) using a continuous frequency-swept tone, which provides significantly more spectral detail, called SFOAE fine structure. A relationship between internal noise and SFOAE amplitudes could reveal that increased difficulty in noise among normal hearing listeners could be related to even minimal loss of outer hair cell function. This could have clinical implications for evaluation and treatment of individuals who report abnormal difficulty hearing in noise with clinically normal hearing.

Design: Thirty young adults (19-30 years) were recruited for the study. All listeners had normal tympanometry, no history of middle ear pathology or surgery, and pure-tone thresholds below 20 dB HL between 0.25 and 8 kHz. SFOAEs were measured with a continuous frequency-swept tones (2 sec/octave, 8 sec/sweep) over 48 sweeps from 0.5 to 8 kHz at 35 dB SPL that provide more spectral details (Long et al., 2008) using OAEToolBox (OTB). A behavioral task was conducted using a sequence of 4 vowel triplets of synthesized English vowels where listeners were asked to judge whether one or two talkers were present. The talkers were nominally differentiated by fundamental frequency (F0 = 120 and 150 Hz) and in location along the azimuth (Œ∏ = 0 and 30 deg, simulated by KEMAR HRTFs). Random perturbation in F0 and Œ∏ (œÉ = 15 Hz and 15 deg) was added independently for each talker on a trial-by-trial basis. Decision weights on F0 and Œ∏ cues for

each listener were estimated from regression coefficients in a general linear model where the perturbation in the cues was the predictor variable for the listener's trial-by-trial response.

Results: A significant but weak correlation (R2 = 0.1606, p=0.03) was found where increases in behaviorally estimated internal noise were related to lower signal-to-noise ratios (SNR) in SFOAE measures, i.e. a smaller difference between individually averaged SFOAE amplitudes and noise floor.

Conclusions: The best predictor for internal noise was found to be SNR measured through SFOAEs, however the correlation was weak. This suggests reduced outer hair cell function is probably not primarily responsible for individual differences in CPL performance among normal hearing listeners. Further studies must explore other potential contributing factors to internal noise estimated from a CPL task.

Poster # 177

Speech is Differentially Susceptible to Noise: Implications for the SII

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Objectives: A long-held assumption is that speech is equally susceptible to noise at every frequency. This belief is reflected in the use of speech-shaped noise to mask speech and in the speech intelligibility index (SII). But there is reason to believe that this is untrue: Our data suggest that speech is differentially susceptible to noise across different frequencies. In fact, the signal-to-noise ratio (SNR) required to equivalently impact various speech bands differs by as much as 13 dB. The objective of the current work is to incorporate this differential noise susceptibility into the SII.

Design: A modified version of the compound band-importance method was employed for the prior determination of noise susceptibility. It was reasoned that, for each target speech band, a certain SNR would produce performance equivalent to no noise present, and another SNR would produce performance equivalent to target-band absent (band obliterated by noise). To obtain a sensitive measure, noise susceptibility for each speech band was defined as the SNR required to reduce the intelligibility contribution of that band by half. If that SNR was similar across frequencies, then noise susceptibility is similar. But instead, it was found that the robustness of each speech band to noise differed substantially across the frequency spectrum. A simple correction factor was proposed to implement this differential susceptibility into the SII.

Results: The SII scales the contribution (importance) of each speech band according to its availability (audibility, A). This is done by multiplying the importance by the value of A for each band. Currently, an SNR of +18 dB is equivalent to no noise (A = 1.0) and an SNR of -12 dB is equivalent to band obliterated by noise (A = 0.0). Each 3 dB change in SNR corresponds to a 0.1 change in the value of A. It is argued that the noise susceptibility of each individual speech frequency band can be incorporated into the SII using a simple correction for each band. This correction simply involves transposing the scale relating SNR to the value of A by an amount equal to the susceptibility of that band (in dB rel. to average susceptibility).

Conclusions: The incorporation of differential noise susceptibility across speech frequencies into the SII is simple computationally and has the potential to improve our understanding of speech cues and our estimation of intelligibility based on them.

Poster # 178

Listening Preference of Emotional and Neutral Speech Between Compression Speeds
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Objectives: The current study investigated how the speech materials influence the preference ratings for overall hearing aid sound quality when comparing amplitude compression algorithms. Specifically, the preference was examined using neutral and emotional speech. Speech in different emotion states is produced with distinct changes in speech production, and emotions are normally perceived through deviations from the normal/neutral state. One of the speech prosody features that conveys emotion is intensity contour. Amplitude compression, which provides time-varying gain so that more gain is available for soft level sounds, while less gain is provided during loud level sounds, may reduce the dynamic variation in the amplitude envelope of the input signal. Such changes in the amplitude envelope may distort the suprasegmental intensity contour cues of the speech. This may impede the listeners ability to use this information and may play a role in the acceptance of the sound. We hypothesize that the amplitude compression algorithm that better preserves the amplitude envelope will be preferred by the listeners, and that the preference is heightened for emotionally valanced speech.

Design: Subjective sound quality preference ratings for neutral and emotional speech were collected in a sample of 20 hearing impaired and 21 normal hearing older adults in a pairwise comparison. The processing conditions included in the comparison were fast acting compression (FAC) and variable speed compression (VSC). VSC system uses two compressors, one with a slow gain regulation and the other with a fast gain regulation, operating at the same time with the final gain depending on the contributions from both compressors. The principle behind this design is to preserve the temporal envelope (via slow gain regulation), while providing extra audibility cues (via fast gain regulation) when needed.

Results: The hearing-impaired listeners showed a strong overall subjective preference for variable speed compression over fast-acting compression when listening to emotionally valanced speech. The same listeners showed moderate, but non-significant, preference for VSC over FAC when judging the preference for neutral speech. Older normal hearing listeners showed preference for VSC over FAC for both neutral and emotional speech materials.

Conclusions: The current study demonstrated that the use of emotionally valanced speech materials may be more sensitive than neutral speech in differentiating between amplitude compression algorithms when using overall sound quality preference as a criterion. Data showed that the listeners prefered variable speed compression over fast acting compression particularly when listening to emotional speech. In the light of this data, clinicians should consider including emotionally valanced speech materials when evaluating listener preference for different hearing aid processing options in the clinic. Because emotionally valanced speech is part of real-life communication, its inclusion in clinical evaluation of hearing aid processing may have better ecological validity than the use of neutral speech.

Poster # 179

Effects of Hearing Aid Processing, Environmental Factors in Virtual Restaurant
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Objectives: The goal of the present study was to create a realistic virtual listening environment and test the effects of digital noise reduction, wide dynamic range compression speed, signal-to-noise ratio, and reverberation time on speech intelligibility. Digital noise reduction and wide dynamic range compression speed were simulated using custom MATLAB software.

Design: We constructed a large virtual environment (20x20x10ft) similar to a restaurant. The T60¬ was either 0.8 or 1.8 seconds. The target talker was directly in front of the listener, 2m away. Six competing talkers were placed in the environment at various virtual tables far away from the target talker. SNR was varied randomly from trial-to-trial with a mean of 0 dB and a standard deviation of 2 dB. Target and masker sentences were both IEEE sentences. The target sentence was never used as a masker in the same trial. Sentences were spatialized, then processed using a hearing aid simulator. Two compression speeds were tested: slow (attack time: 100 ms, release time: 2000 ms) and fast (attack time: 5 ms, release time: 50 ms). Digital noise reduction was either on or off. Spectral noise was estimated using the method in Arslan 1995 and the maximum attenuation was 10 dB. Stimuli were shaped according to gain appropriate for an N3 loss and presented at 65 dB SPL to the listeners. Both the spatialization and hearing aid simulation were completed in MATLAB.21 listeners with clinically normal hearing were recruited to participate in this study. Listeners were recruited by placing flyers around Northwestern's campus. Listeners were seated in a double-walled sound booth with headphones on. They were asked to repeat the sentence spoken by the speaker they perceived to be directly in front of them. SNR and T60 were randomized within blocks. Hearing aid processing strategy was blocked. Blocks were presented in a random order.

Results: There was a significant interaction between digital noise reduction and wide dynamic range compression speed. Listeners had the highest percent correct in listening conditions with slow compression regardless of digital noise reduction condition. Listeners had the lowest percent correct with fast compression and no digital noise reduction; however, their performance recovered to nearly their performance in the slow compression condition in the listening condition with fast compression and digital noise reduction on. SNR was a significant predictor of the results across all processing conditions. Further results will be discussed.

Conclusions: Our results suggest that when in realistic (i.e., noisy, reverberant) listening environments, slow compression and fast compression with digital noise reduction produce approximately the same speech intelligibility. Fast compression without digital noise reduction significantly reduced speech intelligibility. Based on this result, fast compression should be paired with digital noise reduction to maximize speech intelligibility.

Poster # 180

Influence of Lexical Factors in Word Recognition and Word Recall

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Objectives: In the development of an auditory working memory task, the Word Auditory Recognition and Recall Measure (WARRM), several aspects were considered, including the lexical factors of the Neighborhood Activation Model (NAM). The current study examines the role of the NAM lexical factors in the word

recognition, judgement, and recall tasks of the WARRM. NAM theory states that when a word is perceived, representations of similar sounding words, a neighborhood, will become more salient for selection from long-term memory. According to NAM theory, the task of determining a target word is influenced by three variables: 1) word frequency, the number of times a word is used in a language, 2) neighborhood density, number of words in a given neighborhood, and 3) neighborhood frequency, the average frequency of the words in a given neighborhood. According to rehearsal models, lexical factors are thought to play a role in the sub-vocal articulation, a method used to maintain a word(s) in working memory, preventing memory decay. For example, if the target word has a relatively low-frequency and shares the same neighborhood as a high-frequency word, the high-frequency word can be erroneously recalled instead of the correct low-frequency word. It is believed that high-frequency words have a more prevalent representation in long-term memory than low-frequency words thus, influencing word recall.

Design: The influence of lexical factors on WARRM task performance was examined in three listener groups: 1) 48 younger listeners with normal hearing (YNH), 2) 48 older listeners with normal hearing (ONH), and 3) 48 older listeners with sensorineural hearing loss (OHL). The WARRM was administered with and without an additional judgement task, where the first letter of the target word must be categorized in the first or second half of the alphabet. The NAM lexical factors of frequency, neighborhood density, and neighborhood frequency were used as independent variables for the dependent variables of word recognition and recall performance in linear regression models.

Results: In the administration of the WARRM that did not include the judgement task, the two older listener groups (ONH and OHL) had a significant effect of frequency on word recall, suggesting that higher word frequency negatively impacted word recall scores . The ONH also had a significant effect of neighborhood frequency on recall, suggesting that higher neighborhood frequency improved recall scores. Interestingly, the administration of the WARRM that did include the judgement task, had no significant effects of lexical factors. Additional analyses are planned to examine NAM variables as function of set size on the WARRM.

Conclusions: Without the judgement task, lexical factors of frequency and neighborhood frequency seem to impact word recall. Nonetheless, the inclusion of the judgement task seems to negate certain influences of lexical factors on word recall, perhaps enriching word items during encoding and limiting word frequency effects. These preliminary results suggest the importance of incorporating influential factors in the design of working memory paradigms.

Poster # 181

Speech-in-Speech Detection Maturation in Children With and Without Hearing Loss

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Objectives: Children with hearing loss experience more difficulty perceiving speech in the presence of a speech masker relative to peers with normal hearing. However, little is known about age-related changes in masked speech perception for children with hearing loss. Therefore, it is not known if the speech-in-speech perception abilities of children with hearing loss improve with increasing age as has been observed for children with normal hearing. The objective of this study was to test the hypothesis that differences in early listening experience among children with and without hearing loss impacts the development of the sound processing

abilities needed to segregate target speech from speech maskers. The prediction was that the performance gap between children with hearing loss and children with normal hearing would increase with age.

Design: Participants were 22 children ages 5-16 years with aided bilateral sensorineural hearing loss and 22 age-matched children with normal hearing. Children with hearing loss were tested while wearing their personal hearing aids at user settings. The spondaic word "playground", produced by a male talker, served as the target. The masker was continuous two-talker speech, composed of two streams of speech recorded from two different male talkers reading from books commonly read by parents of infants. All children were tested using a two-interval, forced-choice, observer-based procedure. After 80% correct performance was achieved in a training phase, an adaptive procedure was used to estimate the speech-in-speech detection threshold corresponding to 71% correct performance.

Results: Results of a linear mixed effects model fitted to the speech detection data showed a significant effect of child group (hearing loss, normal hearing) and a significant effect of age, but no significant interaction between these two factors. These results indicate poorer speech-in-speech detection thresholds for children with hearing loss relative to children with normal hearing, and that thresholds improved in a similar way with increasing age for the two groups of children.

Conclusions: School-age children with hearing loss require a more advantageous signal-to-noise ratio to detect speech in a speech masker compared with age-matched children with normal hearing, but the magnitude of this performance gap remained constant across the age range of children tested. Additional data collection involving preschoolers is ongoing.

Poster # 182

Sound-Field Speech-in-Babble Hearing Scores in Normal and Impaired Hearing Listeners

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Objectives: Sound-field speech perception in multi-talker babble noise entails complex auditory scene analysis, including energetic and informational modulated masking and dynamic binaural processing. These processes are similar to those listeners encounter on a regular basis in everyday life.

Design: In the present study we used sound field versions of a digits-in-noise (DIN) and a narrative-in-noise (NIN) task to compare the hearing ability of normal-hearing (NH, n=20) and hearing-impaired (HI, n=13) adult listeners in encoding phonetically simple stimuli vs continuous, complex speech targets with extensive vocabulary. NH listeners were ≤ 20 dB HL, 0.25-8 kHz in both ears. HI listeners had a loss greater than 20 dB HL at any frequency (0.25 to 8 kHz) in either ear. For both DIN and NIN tasks three separate speakers were used. Target stimuli were always delivered in front (0o), and multi-talker babble noise in front or at ±90o. The subtraction between these measures was the spatial release from masking (SRM). In DIN, digits were homogenized by adjusting the level of each digit to the 50% mean speech-reception-threshold (SRT). Homogenized digits were then presented as triplets in noise through speakers. The DIN-SRT was estimated based on adaptive presentation of digits at varying signal to noise ratio (SNR). In the NIN test, listeners followed two minute long (~320 words) audiobook extracts of a story with edited versions of the printed transcripts presented at three fixed levels of SNR (+5, 0, -5 dB). In each printed transcript, 25 words differed

from the narrated text (e.g. ‘pale’ for ‘fair’). The NIN scores were calculated based on the number of words correctly identified by marking the transcript at each SNR level.

Results: Overall, NH group had significantly lower DIN-SRTs and better NIN scores than HI group. Robust SRM was observed in both groups. However, no significant difference was found between NH and HI in terms of SRM, suggesting the possibility that SRM is in some respect independent from hearing impairment. DIN-SRTs and NIN scores at both 0o and ±90o were significantly correlated with audiometric pure-tone average, in contrast to the SRM that showed an inconsistent relationship with PTA. DIN-SRTs were significantly correlated to NIN test scores, suggesting that a closed-set simple word corpus (e.g., digits) could be generalizable to more cognitively demanding realistic communication scenarios.

Conclusions: More broadly, this study suggests that people with hearing loss may have more difficulty distinguishing spectral than spatial aspects of speech in challenging listening conditions.

Poster # 183

Effects of Formant Overlap on Dichotic Vowel Fusion and Identification

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Objectives: This study investigated how formant overlap between dichotic concurrent vowels influences vowel fusion and identification in listeners with normal hearing. Two sets of synthetic vowels (/i/, /æ/, /ɑ/, and /u/) were used: one set with category exemplars that are representative of the F1 and F2 values observed for natural vowels (quadrilateral vowel space) and one set with category exemplars constrained to maximize the overlap of F1 and F2 values (square vowel space).

Design: Normal-hearing participants (n=4; 3 females, 1 male, 19-24 years old) with audiometric thresholds better than 20 dB from 250 to 4000 Hz were recruited. All participants were native speakers of American English. Participants were seated in a soundproof booth in front of a touchscreen computer with 8 vowel response options, (/i/, /I/, /ɛ/, /æ/, /ɑ/, /ʊ/, /u/, and /ə/), on the screen. Vowel stimuli were presented at 68 dB SPL over headphones, with 240 msec duration and with fundamental frequency (F0) values of 106.9, 151.2, or 201.8 Hz. Participants completed three different tasks: 1) diotic and monaural vowel training with all 8 vowels, 2) dichotic vowel testing with the 4 quadrilateral vowel space stimuli, and 3) dichotic vowel testing with the 4 square vowel space stimuli. For the training, participants were asked to select the single vowel that they heard. For dichotic testing, although there were only 4 stimuli in each set, 8 vowel response options were used to allow listeners to respond with possible fused vowel percepts not in the original stimulus set. Vowels always differed across the ears, while F0 could be the same or different; participants could respond by selecting one vowel if they only heard one vowel (fusion) or selecting two vowels if they heard two vowels.

Results: Preliminary results suggest when two vowels were perceived, the percent correct identification of at least one vowel was overall lower with the square vowel space stimuli compared to the quadrilateral vowel space stimuli. When one vowel was perceived (fused), the fused vowel percepts differed between the two

stimulus sets. In addition, the use of 8 vowel response options showed that the fused vowel percept could differ from either of the two vowels actually presented. Consistent with previous studies, F0 differences between ears decreased vowel fusion for both stimulus sets.

Conclusions: These findings suggest that both formant overlap and F0 differences influence dichotic vowel fusion and identification, and that vowel fusion can lead to perception of a new vowel different from either of the two presented. These results indicate a potential mechanism for speech perception difficulties in the presence of competing talkers, especially for hearing-impaired listeners who fuse dichotic speech more often than normal-hearing listeners. Future studies are needed to examine these effects in hearing impaired individuals.

Poster # 184

Relating Speech in Noise Perception to Encoding Multiple-Rate Envelopes

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Objectives: The objective of the present study is to evaluate the relationship between speech understanding in noise and the neural encoding of envelope cues in speech. It is well known that speech understanding in quiet and in noise are facilitated by fast and slow envelope cues arising from voicing periodicity (70-500 Hz) and syllabic clusters (1-8 Hz), respectively. However, the prediction of speech understanding in noise using neural indices of envelope encoding has revealed varying degrees of success. Potential factors contributing to the variability in study outcomes may be (i) the independent consideration of slow and fast envelope cues, (ii) the use of absolute measures, and/or (iii) limited frequency specificity in the case of vowel stimuli. We hypothesize that evaluating noise-induced changes in the encoding of both slow and fast envelopes in a frequency-specific manner will explain more variance in speech understanding abilities compared to either cue independently.

Design: Twenty young normal hearing adults between 18 and 30 years of age will be recruited. So far, we have completed data collection in five adults. Fast and slow-rate envelope following responses (EFRs) were elicited by the male-spoken token "soosaashee" (1.92 s; fundamental frequency=98 Hz) presented monaurally at 70 dB SPL. The stimulus was modified to simultaneously elicit one slow-rate EFR and 8 fast-rate EFRs-three from the first formants of each vowel (low frequency), three from the second and higher formants of each vowel (mid frequency) and two from fricatives (high frequency). To evaluate noise-induced changes in envelope encoding, the stimulus was presented in quiet and in the presence of speech-shaped noise at signal to noise ratios (SNR) of +14, +4 and -6 dB. EFRs were recorded using a 1-channel vertical montage between the vertex and nape of the neck while participants watched a close-captioned movie. Speech perception in speech-shaped noise was evaluated using the coordinate response measure. The SNR needed to achieve 50% correct recognition (SNR-50) and the slope of psychometric function were computed.

Results: Preliminary data (n=5) indicate that fast and slow-rate EFRs deteriorate as SNR reduces, and parallel the decrease in speech understanding. In particular, as SNR reduced, the amplitude and inter-trial phase consistency of fast-rate EFRs decreased. Although all 8 fast-rate EFRs indicated a similar pattern, the rate of change was greater for the low frequency stimuli. For the slow-rate EFRs, the amplitude at 1.5 Hz reduced as SNR worsened. In the speech-in-noise perception task, the SNR-50 ranged between -10.8 and -7.5 dB SNR.

Conclusions: With additional data, we will assess (i) the relationship between SNR-dependent change in the EFRs elicited at fast and slow rates, and (ii) the relationship between the rate of SNR-dependent change in

neural measures with SNR-50 and the slope of the psychometric function. Findings from the study will be helpful in ascertaining the importance of considering the fast and slow rate envelopes together while assessing variability in speech perception in noise.

Poster # 185

Subjective Perceptions of Clinical and Complex Speech Perception and Localization

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Objectives: Current clinical speech perception tests do not represent the complex real-world environments patients experience daily, and as such do not demonstrate the impact that hearing technology has in such environments. This may explain why the effects of hearing loss and hearing aids (HAs) and cochlear implants (CIs) measured in clinic do not match those reported by patients. The current study collected subjective impressions of participants tested in both typical clinical speech perception test environments and in acoustically-complex environments. Subjective impressions were collected for task difficulty, enjoyability, and similarity to daily listening environments as well as HA benefit.

Design: Adults with normal hearing or bilateral HAs completed five tests. 1. The AzBio clinical test presented to normal hearers at +10, +5, and 0 dB signal to noise (SNR) ratios and HA participants in quiet, +10, and +5 dB SNRs. 2. AzBio sentences presented from 0 degrees azimuth with restaurant noise (Revit, Killion, & Conley, 2007) presented from eight speakers surrounding the participant. HA participants were tested at the SNR at which they achieved 75% correct with no HAs or only the better-ear HA and then at the same SNR with both hearing devices. 3. The Quick Speech-in-Noise (QuickSIN) test was completed in the sound field in three conditions: a clinical-based method, a spatially-separated target (0 degrees) and symmetrically placed babble (+/-90 degrees), and spatially-separated target and babble with a reverberant room simulation (reverberation time of 150 ms) using an eight-speaker 360 degrees array. 4. Sound localization was tested using 250 ms white noise stimuli, presented from one of eight speakers surrounding the participant at 0, 45, 90, 135, 180, 225, 270, and 315 degrees. 5. Multisource sound localization was tested in a multi-talker environment - participants identified how many talkers were present and from which of the eight speakers. Results were scored response time and correct identification of the number of talkers and the loudspeakers. After each test, participants rated their experiences on a survey asking about the difficulty, enjoyability, real-life similarity, and HA benefit of the tasks on a five-point scale.

Results: Preliminary results revealed that both participants with normal hearing and with hearing loss rated all tests to be fairly similar to their daily environments with little differences across clinical and acoustically-complex tests. The restaurant AzBio, multisource sound localization, and reverberant QuickSIN were reported as being more difficult the clinical and single-source localization tests, which is consistent with their poorer performance on those tests. Participants rated their HAs as being helpful for all tests apart from the reverberant QuickSIN that was rated as less helpful. All tests were rated as being relatively enjoyable by participants apart from the participants with HAs reporting the multi-source localization to be not enjoyable.

Conclusions: Complex auditory environments might reveal different effects of hearing loss and amplification and might be considered more ecologically valid, but listeners may not perceive these environments as more similar to their daily listening experiences. They did, however, perceive these environments as more difficult and that HAs provided benefit in these complex environments.

TINNITUS

Poster # 186

Effects of Stimulus Type on Sound Therapy for Tinnitus Management
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Objectives: The purpose of the present study is to compare the efficacy of stimulus types used in sound therapy for tinnitus management using subjective measures. The hypothesis states that the effects of sound therapy may vary across stimulus types.

Design: Sixty individuals suffering from chronic tinnitus participated in the present study. All subjects were randomly assigned to either a broad-band noise sound therapy group or a notched noise sound therapy group and underwent sound therapy with the level set to the mixing point for 6-months. Informative counselling was provided to both groups. Score changes between pre and post-treatment (3 and 6 month) sessions using Tinnitus Primary Function Questionnaire, Korean version and Visual Analysis Scores for loudness and awareness time were measured. All participants were instructed to continue sound therapy for 3 hours, every day.

Results: Both groups showed significant decrement in Tinnitus Primary Function Questionnaire and Visual Analysis Scores. However, there were no statistically significant differences between the two groups.

Conclusions: At the mixing point level, both non-notched and notched type stimuli were equally effective in tinnitus management.

Poster # 187

Association Between Psychoacoustic Measures of Tinnitus and Self-Reported Tinnitus Severity
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Objectives: The Noise Outcomes in Servicemembers Epidemiology (NOISE) Study is a longitudinal epidemiology study evaluating tinnitus and hearing loss in active duty Service members and Veterans recently-separated (within 2.5 years) from military service. The study takes place at two sites, the National Center for Rehabilitative Auditory Research (NCRAR) at the VA Portland Healthcare System (VAPORHCS) in Portland, Oregon and the Department of Defense Hearing Center of Excellence (HCE) at the San Antonio Military Healthcare System (SAMHS) in San Antonio, Texas. The objective of this presentation is to provide data on psychoacoustic measures of tinnitus, and their correlation with measures of tinnitus severity in Veterans and Service members participating in the NOISE Study across both study sites.

Design: Data collection includes: (1) comprehensive audiometric testing; (2) 15-18 questionnaires/surveys, including the Tinnitus Screener, for all participants; (3) tinnitus testing for participants who screen positive for tinnitus with the Tinnitus Screener, which includes two questionnaires (Tinnitus Functional Index-TFI and Tinnitus History questionnaire) and psychoacoustic tinnitus testing (loudness match-LM, pitch match-PM, and minimum masking level-MML) using the computer-automated Tinnitus Evaluation System (TES). Data from 223 participants will be presented.

Results: (1) Small to moderate relationships were found between these psychoacoustic measures and a subjective measure of the impact of tinnitus (the TFI); (2) All measures of LM presented had significant correlations with TFI total score, and subscale scores; these correlations were for the most part weak; (3) PM and MML showed essentially zero relationship to TFI and subscale scores; (4) The strongest relationships observed occurred between the LM at 1 kHz in dB SPL and the total TFI, Intrusive, Quality, and Emotional subscales. These correlations (ranging from 0.35-0.41) are considered moderate; and (5) Generally, stronger relationships were observed between the TFI scores and LMs in dB SPL vs those same LMs in dB SL.

Conclusions: Higher LMs in dB SPL may indicate higher likelihood of hearing loss, and difficulties due to hearing loss are also known to inflate TFI scores, which may in part explain the stronger correlations between these values. Further research should examine whether any changes in measures of tinnitus perception over time may have a stronger relationship with changes in TFI scores than are observed between measures at a single time point. The NOISE study plans to pursue this question with data that will be collected at the 5-year follow-up appointment.