

**American Auditory Society Scientific and Technology Meeting
February 24 – 26, 2022**

POSTER ABSTRACTS

Topic areas and poster numbers:

Topic Area

Poster Numbers

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ANATOMY and PHYSIOLOGY

Category: Anatomy and Physiology

Poster #: 001

Intrinsic Compensatory Mechanisms Shape Sensorineural Outcomes Following Noise Injury

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Objectives: A long history of research has demonstrated that excessive noise exposure will kill sensory outer hair cells (OHCs) in the cochlea. Such observations have fueled the notion that dead OHCs determine the degree and configuration of sensorineural hearing loss. Therefore, previous and current therapeutic approaches are based on preventing the loss of OHCs. However, the relationship between loss of OHCs and sensorineural hearing loss is at best a modest correlation. This suggests that beyond the death of OHCs, intrinsic compensatory mechanisms may regulate the type and degree of sensorineural hearing loss. In the current study, we tested the hypothesis that intrinsic compensatory mechanisms shape sensorineural outcomes following noise injury.

Design: Hooded male rats were randomly divided into noise trauma (N= 9) and control (N = 9) groups. Otoacoustic emissions were deployed to investigate the functional integrity of OHCs before and after traumatic noise exposure. While, action potential recordings were deployed to evaluate the integrity of sensorineural transmission. Additionally, cytochleograms were used to quantify the percentage of dead OHCs.

Results: The combined results suggest that compensatory strategies from surviving cochlear elements shape sensorineural outcomes and not the percentage of dead OHCs.

Conclusions: These findings provide the basis for individualized othotherapeutics that manipulate surviving cellular elements in order to bias cochlear function towards normal hearing even in the presence of dead OHCs.

Category: Anatomy and Physiology

Poster #: 002

Comparison of Ear-Canal Geometry via Imaging and Acoustical Data

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Objectives: Specification of the sound field near the tympanic membrane (TM) of the human ear canal is important in interpreting behavioral/physiological tests of the auditory system at high frequencies. This requires knowledge of the spatial variation of the cross-sectional area along the centerline of the canal, i.e., its area function, which may be directly assessed via three-dimensional (3D) imaging or indirectly assessed by measuring the ear-canal sound field in response to a sound stimulus. This research parameterizes the ear-canal geometry along its curved axis using analyses of ear scans ("shape data") and compares the area function so obtained with that inferred from acoustical measurements ("sound data") of the ear reflection function (RF). The measured RF may be used to estimate the sound pressure near the TM.

Design: A digital ear scan, acquired using a hand-held device, represented the canal wall as a two-dimensional surface image in 3D space. Scan data voxelized with 0.5 mm spatial resolution were modeled as a surface of spatially varying elliptical area and eccentricity. A discrete Frenet frame procedure, which represented how discrete locations along the centerline curved in 3D space, was combined in an iterative approach to fitting the cross-section at each discrete location by an ellipse. Shape outputs were the curvature and torsion of the centerline and the area and eccentricity at each centerline location. Sound data were acquired using a low-level chirp stimulus and analyzed in the time domain from 0.125 to 20 kHz as follows: calibrate using (regularized) deconvolutions of tube data and models to measure the incident pressure and calculate the source RF

comprising the reflection characteristics from the probe, make a leak-free insertion of probe into the ear canal, measure the sound pressure at the probe tip, and calculate the ear RF and entryway area via deconvolutions. The ear-canal area function was calculated with 3.6 mm spatial resolution using a lossy, layer-peeling algorithm. Shape and sound data were collected in adult ears with normal otoscopy and tympanometry.

Results: The ear-canal cross-section is elliptical rather than circular. Area variations along the canal centerline modify high-frequency sound transformation between the probe tip and TM. The sound pressure transformation between the probe tip to a near-TM location is obtained in terms of probe-tip pressure, the ear RF, and the area function. In preliminary findings, the estimated area function is improved by the reflected sound energy at high frequencies and is sensitive to the source RF. Comparisons of shape- and sound-data area functions in the same ear are aligned using a cross-correlation function to determine best overlap, but these interpretations are ongoing.

Conclusions: These measurements represent shape and sound data along the canal centerline in human subjects. Area inferences based on direct and indirect procedures have performance tradeoffs, i.e., in the iterative determination of the centerline in shape data versus the influence of evanescent modes in sound data. These findings are a step to improve the ability at frequencies >4 kHz to transform ear-canal measurements at the probe tip to locations near the TM.

AUDITORY PROCESSING

Category: Auditory Processing

Poster #: 003

Listening Difficulties in Children with Autism Spectrum Disorder

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Objectives: Communication challenges are common characteristics of Autism Spectrum Disorder (ASD); however, listening deficits may be underestimated in this population because routine audiometric assessments do not include measures of auditory processing, complex speech recognition, and functional listening ability. This retrospective study examines auditory functioning in children with ASD and investigates auditory challenges in this population. Participants presented with normal sound detection thresholds but reported auditory concerns related to auditory filtering skills, speech recognition, binaural integration.

Design: This retrospective study reviewed clinical data and questionnaires in 71 patients between the ages of 6 – 14 years ($M = 9.3$, $SD = 2.1$), who were seen at listening clinics in the United States and Australia. Inclusion criteria was a positive history of ASD and normal pure-tone hearing sensitivity bilaterally (<25 dB HL at octave frequencies from 250 – 8000 Hz). Data were excluded for children with known intellectual impairment. Caregivers of participants completed case history forms as well as the Short Sensory Profile 2 questionnaire. Clinical assessments across two sessions were comprised of speech recognition in noise, binaural integration (dichotic digits), and auditory and visual attention. General auditory processing was conducted to evaluate auditory short-term memory, working memory, and listening comprehension.

Results: Questionnaires revealed the most common parent-reported issue was aversion to noise (73%). Over 40% of patients with ASD exhibited significantly reduced speech recognition in noise and abnormal binaural integration that was not attributed to deficits in attention. The majority of these patients performed abnormally on at least one auditory task, suggesting that functional auditory issues exist in patients with ASD despite normal pure-tone sensitivity.

Conclusions: The rate of parent-reported sensory issues, speech recognition in noise, and dichotic listening deficits observed in patients with ASD were significantly higher than expected compared to a theoretical neurotypical population. These findings support the need for a holistic and comprehensive assessment for patients with ASD. Incorporating measures beyond the audiogram positions hearing healthcare providers to identify and potentially mitigate listening challenges through management, improving hearing and communication, as well as quality of life for children with ASD.

Category: Auditory Processing

Poster #: 004

Effects of Stimulus Rate and Periodicity on Auditory Cortical Entrainment and their Relation to Speech Rhythms

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Objectives: We investigated auditory temporal processing in children with amblyaudia (AMB), a subtype of auditory processing disorder, via cortical neural entrainment.

Design: Evoked responses were recorded to click-trains at slow vs. fast (8.5 vs. 14.9/sec) rates in $n=14$ children with AMB and $n=11$ age-matched controls. Source and time-frequency analyses decomposed EEGs into oscillations (reflecting neural entrainment) stemming from the bilateral auditory cortex.

Results: Phase-locking strength in AMB depended critically on the speed of auditory stimuli. In contrast to age-matched peers, AMB responses were largely insensitive to rate manipulations. This rate resistance was seen regardless of the ear of presentation and in both cortical hemispheres.

Conclusions: Children with AMB show a stark inflexibility in auditory cortical entrainment to rapid sounds. In addition to reduced capacity to integrate information between the ears, we identify more rigid tagging of external auditory stimuli. Our neurophysiological findings may account for certain temporal processing deficits commonly observed in AMB and related auditory processing disorders (APDs) behaviorally. More broadly, our

findings may inform communication strategies and future rehabilitation programs; increasing the rate of stimuli above a normal (slow) speech rate is likely to make stimulus processing more challenging for individuals with AMB/APD.

Category: Auditory Processing

Poster #: 005

Burn Pit Exposures and Auditory Dysfunction Among US Military Personnel

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Objectives: Auditory disorders are often associated with occupational exposures to noise, chemical/solvent exposure, or otoacoustic trauma during active-duty military service. Some studies have investigated relationships between chemical/solvent exposures and auditory disorders. However, to our knowledge, none have addressed potential adverse auditory effects of exposure to military burn pits (BP), which can emit harmful toxic substances and chemicals. The objective of this study was to explore possible relationships between BP exposure and auditory disorders (tinnitus, hearing loss) that are common among military Service members and Veterans.

Design: Data presented here were derived from baseline assessments of 636 research participants enrolled in the Noise Outcomes in Service Members Epidemiology (NOISE) study. Included in this analysis are participants who responded "yes" or "no" when queried about BP exposure during military deployment. Pure tone averages (PTA) were calculated for low-frequency (250, 500, 1000, 2000 Hz) and high-frequency (3000, 4000, 6000, 8000 Hz) hearing thresholds. Hearing loss in each frequency range was defined as PTA >20 dB HL. Tinnitus status was determined using the Tinnitus Screener questionnaire. For the purpose of this analysis, data from participants who reported constant or intermittent tinnitus were collapsed into the "tinnitus" category, while data from participants who reported none, occasional, or temporary tinnitus were collapsed into the "no tinnitus" category. We examined associations between BP exposure, PTAs, and tinnitus using multivariable logistic regression analyses.

Results: Mean age of the study sample was 35 years (sd=9.0); 76% (486/636) were male. About 40% of the sample was comprised of active-duty Service members and 60% were Veterans. Fifty-seven percent of Service members and 62% of Veterans reported exposure to BP during a period of deployment. Combining Service members and Veterans, 12% had low-frequency hearing loss, 24% had high-frequency hearing loss, and 56% had tinnitus. After controlling for age and gender, no associations were seen between reported BP exposure and low-frequency hearing loss (OR=1.1, 95% CI: 0.4, 2.8), high-frequency hearing loss (OR=1.2, 95% CI: 0.6, 2.2), or tinnitus (OR=1.5, 95% CI: 0.9,2.5) among Service members. However, Veterans who reported exposed to BP were almost twice as likely to have high-frequency hearing loss (odds ratio [OR]=1.8, 95% confidence interval [CI]: 1.1, 3.0) and 1.5 times more likely to report tinnitus (OR=1.5, 95% CI: 1.0, 2.4) compared to those who were not exposed to BP.

Conclusions: Self-reports of BP exposure were prevalent (>50%) in our sample of post-9/11 Service members and Veterans. The Veterans, but not Service members, had increased odds of hearing loss and tinnitus among those exposed to BP compared to those unexposed. These findings suggest that, Veterans exposed to BP may be at higher risk for auditory dysfunction. Limitations to this study include: (1) BP exposure was self-reported and may be prone to recall bias; (2) the cross-sectional analysis precludes drawing causal conclusions; and (3) we were unable to account for BP exposure time. Further research is necessary in a longitudinal framework regarding the strength and consistency of the associations found in this study, and the granularity of BP exposure time.

COCHLEAR IMPLANTS

Category: Cochlear Implants

Poster #: 006

Using ECAPs to Predict Detrimental Effects of Interaural Mismatches

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Objectives: Interaural mismatch decreases sensitivity to binaural cues such as interaural time differences (ITD) for bilateral cochlear implant (CI) users. Poor sensitivity to ITDs can lead to a degradation of localization and lateralization abilities. However, the effects of interaural mismatch may be mitigated by the amount of current spread. Current spread can be estimated using spread of excitation (SOE) functions, which measure the extent to which electrodes stimulate overlapping neural populations by measuring evoked compound action potentials (ECAPs) in response to stimulating different electrodes. We hypothesized that a broader SOE would correspond to less sensitivity to interaural mismatches. The goal of this study is to determine if the SOE functions can predict the effect of interaural mismatch on CI users' ITD thresholds.

Design: SOE functions were measured for multiple probe electrodes across the array using a forward-masking subtraction method using Cochlear's Custom Sound EP software. Participants also completed an ITD detection task that measured the ITD thresholds for different interaural electrode pairs.

Results: Results indicate that SOE functions and ITD threshold functions differ across participants.

Conclusions: This study will help determine if SOE measures can be used to predict which CI users will have more difficulties with interaural mismatches. Future studies will investigate the relationship between SOE width and other binaural cues such as ILDs.

Category: Cochlear Implants

Poster #: 007

Predicting Cochlear Implant Outcomes Using Filtered High Frequency AZBio Sentences

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Objectives: Establishing appropriate expectations for cochlear implant outcomes is challenging. Many individuals undergo this operation without knowing what expected performance they may achieve. Because speech understanding is highly dependent on high frequency audibility, a cochlear implant aims to restore access to these sounds. The aim of the present study is two-fold: 1) To determine if there is a significant improvement in speech understanding using filtered high frequency speech information at the cochlear implant candidacy evaluation, and 2) to determine the relationship between pre-implantation and post-operative performance at one month. We hypothesize that improved audibility with additional high frequency speech information will predict speech understanding in quiet at one month.

Design: Preliminary data includes ten adult participants who completed a cochlear implant evaluation at Mayo Clinic Arizona [Male = 80%, age range = (mean: 80.1 years, SD: 4.5, 73-85)]. All participants demonstrated significant bilateral sensorineural hearing loss (PTA = 76.9, 60-90 dB HL) and did not perceive sufficient benefit from their current amplification. All participants were fit with hearing aids using Real-ear verification to ensure that NAL-NL2 prescriptive listening targets were met. Speech perception testing was completed in the sound field at a presentation level of 60 dB SPL(A) using computer generated speech at 0 degrees azimuth. Two lists of AzBio Sentences were presented in the best-aided bilateral condition in quiet, one standard list and one list with an additional 14 dB of gain for frequencies above 1000 Hz. Differences in performance on these two lists will be documented, categorizing outcomes in terms of percent change. Participants will be followed through their one-month post-activation evaluation and will complete AZBio sentence testing for the implanted side. Data from these follow up evaluations will be compared to pre-implantation scores.

Results: Candidacy evaluations have been completed on 10 participants. Of these, seven averaged 15% (range = 6-29%) improvement on speech understanding with the additional high frequency information in quiet. Interestingly, three participants demonstrated a mean decline in performance of 8.6% (range = 5-11%) in this condition. Three of the ten have been implanted and are scheduled for upcoming activations by the end of this year. The remaining participants are in the process of scheduling surgery. All follow up data will be collected by February 2022.

Conclusions: Identifying predictors for post-operative cochlear implant outcomes will improve our ability to provide patients with appropriate expectations. This is a significant challenge as many components contribute to outcomes that are often out of the patient's and clinician's control. There are likely numerous that remain unknown. However, pre-implantation markers of auditory perception and neural integrity as assessed by speech understanding may provide clues to understanding expected patient performance post-operatively.

Category: Cochlear Implants

Poster #: 008

Differences Between Pediatric Cochlear Implant Recipients with EVA and Connexin-26

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Objectives: Previous work in our lab has highlighted the electrode neuron interface and its contribution to the wide variability in cochlear implant (CI) outcomes. Electrode neuron interface describes the relationship between the electrodes and the spiral ganglion neurons they aim to stimulate. For this study, we focused on two common etiologies of severe to profound pediatric hearing loss, Enlarged Vestibular Aqueduct (EVA), and Connexin-26 mutation, which we hypothesize represent extreme ends of the quality spectrum of electrode neuron interfaces. In EVA, cochlear malformations are common, and poor electrode neuron interface quality is expected. With Connexin-26 mutations, cochlear anatomy and spiral ganglion cell counts are typically normal, and relatively good electrode neuron interface quality is expected. We compared patients with these two etiologies to determine if the hypothesized differences in electrode neuron interface were observable in clinical CI data and speech outcomes.

Design: In this retrospective chart review, we queried the audiology databases of two CI centers in the Boston area. We included pediatric CI ears with confirmed diagnoses of EVA or Connexin-26 mutation with data from at least 6 months post-activation with Cochlear or Advanced Bionics devices. Patients with confounding diagnoses or failed/extruding devices were excluded. Ultimately the dataset contained 138 children (222 ears): 68 children (110 ears) with EVA and 70 children (112 ears) with Connexin-26 mutation. Data gathered included demographics, CI manufacturer, internal device, electrode array, threshold and upper stimulation levels, impedances, and speech performance.

Results: Children with EVA have higher thresholds, higher upper stimulation levels, and higher impedances than children with Connexin-26 mutation, for both manufacturers. Of the children with available speech recognition scores, 76 Connexin-26 mutation ears and 44 EVA ears had performed recorded consonant-nucleus-consonant (CNC) words, the most difficult word test in the Pediatric Minimum Speech Test Battery. There was no significant difference in performance between these two groups when controlling for duration of CI experience. However, 79% of the Connexin-26 mutation dataset had CNC data, compared to only 52% of the EVA group, suggesting that many children with EVA were unable to complete this difficult test. Additionally, children with Connexin-26 mutation were implanted earlier on average, and had longer durations of CI experience, making it difficult to disentangle the effects of etiology, electrode neuron interface, and CI experience on speech performance outcomes.

Conclusions: Pediatric CI recipients with EVA required more current for sound perception and optimal loudness, and had higher impedances than pediatric CI recipients with Connexin-26 mutation. These systematic differences could be related to differences in the electrode neuron interface quality. Future work may elucidate whether electrode to modiolus distances differ between these groups and what drives the increased impedances for children with EVA. Regarding speech outcomes, for the subset of patients who completed CNC testing, scores did not differ. However, more work is necessary to understand why fewer pediatric CI listeners with EVA were able to complete challenging CNC testing. Understanding these differences may be helpful for programming children too young to make multiple behavioral responses, and may inform future research regarding patient-specific programming guidelines.

Category: Cochlear Implants

Speech Perception with Interleaved Frequencies Across Ears in Cochlear Implants

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Objectives: Cochlear-implant (CI) users have a difficult time understanding speech in noisy environments, partly because of CI users' poor spectral resolution. Channel interaction in a CI causes poor speech perception in noise. Interleaving the signal between the ears has improved within-ear masking due to channel interaction for hearing impaired listeners. Interleaved processing in CI users may improve spectral resolution and speech perception, due to providing more channels of stimulation with less channel interaction, but may impair spatial hearing. The current study examined monaural and binaural spectral resolution and speech recognition in co-located and spatially separated multi-talker environments to determine if listeners with CI simulations can integrate frequency bands across ears for better speech perception.

Design: Forty-one normal-hearing adults participated in the study (30 females and 11 males). Participants completed three experiments: adaptive spectral-temporally modulated ripple test (SMRT), sound localization, and speech recognition. The SMRT measured spectral resolution using spectrally and temporally modulated noises resulting in a threshold in ripples per octave. Sound localization was tested using white noise presented at roving levels from eight azimuths in the rear-hemifield using non-individualized head-related impulse responses (HRIRs). A speech recognition threshold was measured with co-located and spatially-separated target and masker sentences presented at 60° and -60° azimuth, using the HRIRs described above. Co-located speech recognition was tested in unilateral and bilateral conditions to examine binaural integration. The spatially-separated condition was only tested bilaterally. The effects of interleaving frequency bands across ears were tested using uncorrelated 12-channel noise vocoders with interleaved and non-interleaved channels, with odd channels presented to one ear and even to the other. Two conditions of interleaving were tested. The first deactivated channels in each ear to reduce within-ear masking but keep the same total number of channels at 12. The second narrowed the input frequency bands sent to each channel with all simulated electrodes active for a total of 24 channels.

Results: Data revealed that spectral resolution increased with the second condition of interleaving for more spectral channels, but was primarily a monaural effect with narrower input filters with little binaural integration of spectral channels for better spectral resolution. There was limited speech perception benefit with both ears in a co-located condition, but the two-ear benefit was greater with interleaved complementary information across ears than with non-interleaved vocoders. Degree of error for localization was slightly worse with traditional bilateral CI processing than unprocessed stimuli and even slightly worse with interleaved frequency bands. Finally, spatial release-from masking (SRM) was somewhat impaired with interleaved frequency channels across ears, especially with deactivated channels.

Conclusions: Interleaving frequency bands for CIs may increase spectral resolution but will likely negatively impact spatial-hearing abilities. Current results indicate improvements in spectral resolution may be unilateral, resulting from decreased channel interaction and narrower input filters. Listeners with CI simulations can integrate interleaved frequency bands across ears for speech perception, although the benefit was small. SRM results indicate that spatial hearing benefits were larger than spectral benefits and should be maintained.

Poster #: 010

Training Effects for Different Types of Cochlear Implant Simulations

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Objectives: Bilateral CIs can be programmed with identical or complementary (interleaved) frequency cues across ears. Complementary cues across ears may improve resolution and clarity. Research has shown, however, that listeners with CIs might struggle to integrate complementary cues across ears or require training to do so. This study used different CI simulations to address the following research questions: 1) Can normal-hearing listeners integrate CI simulations with complementary cues across ears for better speech understanding? and 2) Does speech perception with training differ for CI simulations with identical or complementary cues across ears as well as with and without frequency shifting to different cochlear regions?. We hypothesized that participants will obtain more benefit from training for CI simulations with neural shifts in frequency and complementary cues across ears. We also predict that participants will be able to integrate complementary cues across ears, but only after training.

Design: Adults with normal pure-tone thresholds were recruited. The effects of interleaving cues and upward spectral shifts were examined with four 12-channel uncorrelated noise vocoders: 1) identical cues across ears without an upward spectral shift of frequencies, 2) complementary/interleaved cues across ears without an upward spectral shift of frequencies, 3) identical cues across ears with an upward spectral shift of frequencies, and 4) complementary/interleaved cues across ears with an upward spectral shift of frequencies. The order of the vocoder conditions was randomized across participants. Participants completed baseline speech testing in unilateral and bilateral co-located and spatially-separated conditions, 45 minutes of training with auditory vowels and consonants with feedback, and repeated speech testing in one and both ears to measure change in performance from baseline and binaural integration. Outcome measures were speech recognition thresholds in noise for baseline and post testing as well as the change in percent correct in vowel and consonant recognition during training. Statistical analyses were completed with a linear mixed effects model for each outcome measure separately.

Results: The data from both the vowel and the consonant testing show that participants could integrate CI simulations with complementary cues across ears for better speech understanding. There wasn't a lot of learning overall, but there was more learning with the shifted conditions than there was with the unshifted conditions. Whether the signal was complementary or identical had more of an effect on the performance than whether it was shifted or unshifted, but as predicted, the condition where participants struggled the most was with both complementary cues and shifts.

Conclusions: Our preliminary data support our hypothesis that participants would obtain more benefit from training for CI simulations with neural shifts in frequency, however not for CI simulations with complementary cues across ears. The data also support our hypothesis that participants can integrate complementary cues across ears, but they did not require training. This study indicates potential for future clinical CI programming that includes complementary frequency cues that must be integrated across ears, but further research is needed in individuals with CIs.

Category: Cochlear Implants

Poster #: 011

EAS Use and Benefit in Adults and Pediatric CI Users

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Objectives: The use of electric and acoustic stimulation (EAS) in adults with cochlear implants (CI) has demonstrated benefits of low-frequency acoustic hearing preservation including important cues for listening in noise, localization of sound, and enhanced sound quality. However, the benefit of EAS over electric-only stimulation in a given patient is highly variable and difficult to predict from an audiogram. Additionally, the use and potential benefits of EAS in the pediatric population has received less study. While children with hearing loss may have similar audiograms to post-lingually hearing impaired adults, different etiologies may have implications for its benefit. The primary objective of this investigation is to determine if adults and children with sloping hearing losses have similar abilities to process super-threshold auditory information using a spectral-temporal test (SMRT) as age-matched controls.

Design: Spectral-temporal resolution was assessed with the spectral-temporal modulated ripple test (SMRT) for adults and children who had acoustic hearing with steeply sloping audiograms typical of EAS candidates. Age-matched normal hearing (NH) controls listened to stimuli through low-pass filters and at two levels (40 and 60 dBA) to simulate low and high audibility. NH simulations describe a “best case scenario” for hearing loss where audibility is the only deficit. Listeners with hearing loss listened to SMRT stimuli unaided at their most comfortable listening level and speech stimuli at 60 dBA. Speech perception was measured with age-appropriate materials.

Results: In adults, performance on the test (avg. 1.6 RPO) was much lower than that of normal hearing controls using a low-pass filtered version of the test to simulate a typical sloping audiogram (avg. 5.5 RPO). In children, pilot data suggest that pediatrics perform better than adults with similar hearing loss on SMRT (avg. 3.4 RPO), though still below listeners with NH, suggesting performance is not completely attributable to audibility. Relationships between age, SMRT score, and audiometric thresholds will be described.

Conclusions: In adults, despite similar audibility on audiometry, the differences in SMRT scores suggest differences in how well the residual hearing is able to process suprathreshold auditory information (i.e. the “quality” of the residual hearing), which may influence auditory abilities thought to be enhanced by residual acoustic hearing with a CI. The broadening of auditory filters, loss of cochlear nonlinearities, and possible cochlear dead regions may contribute to distorted spectral resolution and thus deviations from the NH simulations. Comparatively, we did not observe a consistent deficit in children with sloping hearing losses.

DIAGNOSTIC AUDIOLOGY / OTOTOLOGY

Category: Diagnostic Audiology / Otology

Poster #: 012

A Battery for Adults with Self-Reported Hearing Handicap

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Objectives: Despite a diagnosis of normal hearing, many people experience hearing disability in their everyday lives. This study compared the standard diagnostic battery and an experimental supplemental battery in their ability to explain variance in self-reported hearing disability and handicap and predict whether a person will report a significant disability.

Design: Adults with clinically normal hearing were asked to complete the 12-item version of the Speech, Spatial, and Qualities of Hearing Scale and the Hearing Handicap Inventory for Adults as measures of self-reported hearing disability and handicap, respectively. Participants completed the standard diagnostic battery, including audiometric thresholds, a word recognition task, and sentences-in-noise task; and an experimental supplemental diagnostic battery including extended high frequency thresholds, a survey of listening effort, and auditory and non-auditory tests of working memory, executive function, and attention. The variance explained by the standard and experimental battery were compared, and a model was built to predict the hearing disability and handicap reported by individual participants. Furthermore, the benefit of adding the experimental supplemental battery to the standard battery was compared to the cost of the added time it takes to complete the experimental supplemental battery.

Results: Preliminary data suggest that significant variance in hearing disability and handicap is explained by audiometric thresholds, even when thresholds are considered normal. Furthermore, variance explained by cognitive measures exceeds that explained by performance on word and sentence recognition tasks in this sample.

Conclusions: A diagnosis of normal hearing does not align with self-reported disability or handicap, though higher audiometric thresholds are associated with more reported disability and handicap. Auditory cognitive measures may provide insight into patient complaints when standard auditory tests do not explain patient complaints.

Category: Diagnostic Audiology / Otology

Poster #: 013

Documenting Problems from Hyperacusis using Open-Ended Questionnaires

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Objectives: Hyperacusis is a debilitating condition that includes negative reactions to sounds that are too loud, annoying, fearful, and/or painful. People with hyperacusis often present with psychosocial and functional impairments affecting their quality of life that include difficulties at the workplace or in attending social situations. Self-report measures are often used to document these symptoms in a clinical setting, though research on their use with hyperacusis patients is limited. One of the most commonly used questionnaires, the Hyperacusis Questionnaire (HQ), has poor reliability and weak clinical utility. Therefore, we adapted an open-ended tinnitus questionnaire, referred to as the Hyperacusis Problems Questionnaire, to document specific problems resulting from hyperacusis that were not previously understood. We recently modified the Client Oriented Scale of Improvement for use with hyperacusis patients, creating a new questionnaire (i.e., the COSI-H) to track the degree of benefit from intervention. The aim of this preliminary study is to validate the Hyperacusis Problems Questionnaire and the COSI-H that are used to assess problems resulting from

hyperacusis and to determine the sensitivity of the two measures by comparing responses before and after intervention.

Design: We gathered preliminary data from 25 patients with hyperacusis who received clinical intervention from one of two sites: 1) the University of Iowa Hospitals and Clinics or 2) Augustana College Center for Speech, Language, and Hearing. All participants completed the open-ended Hyperacusis Problems Questionnaire, a 25-item Hyperacusis Intake Questionnaire, and a subset completed the COSI-H. Questionnaires were administered before and after counseling and sound therapy interventions.

Results: Participants were severely bothered by hyperacusis with a severity rating of 82.2/100. On the Hyperacusis Problems Questionnaire, participants reported a decrease, ranging from 60-100%, in the number of problems related to hyperacusis. Additionally, treatment significantly improved hyperacusis symptoms who experienced no problems after therapy. Some of the problems reported on the Hyperacusis Problems questionnaire included avoiding social situations and group settings, trouble concentrating or focusing on tasks, having anxiety or panic attacks, being around family or friends, avoiding loud situations, and experiencing pain or headaches. For the COSI-H, 20 problems were reported which ranged from interference at work, an inability to concentrate at school, and emotional distress. Patients reported their symptoms were better after therapy (12/20 or 60%) and some even much better (3/20; i.e., struggling at school, being around family). No patient reported problems from hyperacusis to be worse after therapy on the COSI-H.

Conclusions: Open-ended questionnaires are helpful tools in the assessment of hyperacusis symptoms and the documentation of treatment effectiveness that address the specific problems resulting from hyperacusis. Research should continue to evaluate outcome measures for hyperacusis with a larger patient population.

Category: Diagnostic Audiology / Otology

Poster #: 014

Sensorineural Hearing Loss in Patients with Irritable Bowel Disease

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Objectives: According to the Centers for Disease Control, 1.3% of or 3 million Americans have irritable bowel disease (IBD) (either Crohn's disease [CD] or ulcerative colitis [UC]) which is chronic inflammation of the gastrointestinal track and is associated with reduced quality of life, poor health, and increased healthcare expenditures. People with IBD frequently have other chronic health conditions such as cardiovascular, kidney, liver, and respiratory disease; arthritis; cancer; and migraine headaches. Sensorineural hearing loss (SNHL) has also been reported as an extra-intestinal manifestation (EIM) of IBD. Our aim was to determine the prevalence for and the clinical manifestations of SNHL in patients with IBD.

Design: A systematic review involved independent searches of PubMed, Cumulative Index to Nursing and Allied-Health Literature, Cochrane Collaboration, and Google Scholar during November 2021. The authors used a consensus approach to assess the quality of the articles and extract data for the meta-analysis.

Results: Of the 37 articles recovered for full-text review, 10 provided group data for potential inclusion in a meta-analysis, 21 were case studies, and six were review articles. Patients with IBD were about four times more

likely to develop SNHL than healthy controls (OR = 3.86; 95%CI = 1.21 to 12.2; z = 2.29; p = 0.02). In a prospective, blinded cross-sectional study, prevalence of SNHL for adults with IBD was found to be 38% versus 4% for healthy controls. However, the prevalence of SNHL was 52% for those with other EIMs and/or who were >40 years. Other reports without control groups have found the prevalence of SNHL to be as high as 50 to 60% in adults with IBD. A larger number of studies reported on adults with UC rather than CD. Studies with pediatric patients with IBD found elevated thresholds for high frequencies >8 k Hz compared to control groups. The clinical course of SNHL with IBD suggests a preclinical period of decreased DPOAE amplitudes and increased hearing thresholds for high frequencies >8 kHz followed by either a progressive or sudden SNHL. Systematic inflammatory responses from IBD cross the blood-labyrinthine barrier resulting in an autoimmune SNHL which may respond to immunosuppressive therapy.

Conclusions: SNHL is common in patients with IBD, particularly for those with other EIMs and/or who are >40 years. Patients with IBD should be made aware of the possibility of SNHL and seek assistance immediately if experiencing a sudden change in hearing sensitivity.

Category: Diagnostic Audiology / Otolology

Poster #: 015

Characterization of Trends in Current Audiologic Practices

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Objectives: The purpose of the study was to characterize trends in current audiologic practices. Specifically, we sought to answer the following research questions: First, what clinical practices do current U.S. audiologists report as part of their standard care? Second, how have these trends changed over the past decade?

Design: An online survey was posted to audiology-related social media groups. This survey asked audiologists to indicate their clinical activities and how frequently they performed them. 77 audiologists located across the United States responded to the survey.

Results: More than half of the audiologists (53-62%) reported using validated fitting prescriptive methods and evaluating treatment outcomes using behavioral speech in noise testing and self-report questionnaires. However, the current study shows that slightly less than half of the audiologists reported conducting frequency-specific pre-fitting measures, providing comprehensive audiologic rehabilitation and counseling, and adhering to professional recommendations for best practices for verifying hearing aid electroacoustic and real-ear performance. These results are consistent with data from the 2014 and 2016 ASHA Audiology surveys that also showed fewer than half of practicing audiologists adhere to best practices for hearing aid provision.

Conclusions: Despite professional associations' recommendations and research evidence in favor of providing comprehensive audiologic rehabilitation when fitting and dispensing hearing aids, slightly less than half of audiologists reported adhering to these guidelines. In the modern landscape of clinical care, it is critical that professional audiologists operate at the top of the scope of rehabilitative practices in order to demonstrate the positive impact that professional services can provide when compared to outcomes with direct-to-consumer hearing aids.

Category: Diagnostic Audiology / Otology

Poster #: 016

Assessing Neural Deficits in Patients with Sensorineural Hearing Loss

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Objectives: Age-related hearing loss results from loss of sensory cells, as reflected in audiometric threshold elevation. Recent studies from animal models and human temporal bones show that outer hair cell loss can be preceded by loss of synaptic connections between the inner hair cells and a subset of auditory-nerve fibers. The silencing of these neurons with high thresholds and low spontaneous rates degrades auditory processing and likely translates into a variety of perceptual abnormalities, whether or not sensory cell function is compromised. This retrospective study tests the hypothesis that patients with sensorineural hearing loss show deficits in word recognition tasks that cannot be entirely explained by a loss in audibility.

Design: We collected audiological data from large cohorts of patients seen at Mass Eye & Ear between 1993 and 2017 with 1) normal hearing sensitivity (n=36,855 ears); i.e., thresholds ≤ 20 dB HL across standard audiometric frequencies or 2) bilateral and symmetrical sensorineural hearing loss (SNHL; n=44,967 ears); i.e., patients with no air-bone gap and no inter-aural asymmetry in AC thresholds. No patients with a known disease, disorder or condition related to the ear or hearing (other than aging) were included in the latter group. For comparison, a third group of patients with conductive hearing loss was included (n=8,301 ears); i.e., patients with an air-bone gap ≥ 15 at any test frequency. Word recognition was assessed using CNC word lists presented with a contralateral masker. The Articulation Index was used to predict the speech intelligibility curve (SIC) using a transfer function for CID W-22. The level at which maximal intelligibility was predicted was chosen as presentation level (no less than 70 dB HL).

Results: Differences between measured word recognition scores and word scores predicted by the SIC increased significantly with age, pure-tone average (0.5, 1 and 2 kHz) and mean AC thresholds in patients with SNHL. This relationship was absent in age-matched patients with matched degrees of conductive hearing loss. In patients with predicted word scores $\geq 99\%$, measured scores could be as poor as $\sim 40\%$ despite a mild to moderate hearing loss. Studies of human temporal bones show that loss of cochlear neurons is one of the most common histopathological features of SNHL. In animal studies, aging preferentially damages the cochlear neurons with high thresholds that respond to presentation levels ≥ 70 dB HL. A loss of these neurons could therefore be a major contributor to the observed difficulties in speech discrimination.

Conclusions: Speech intelligibility deficits that cannot be entirely explained by loss in hearing sensitivity are consistent with cochlear nerve degeneration and/or loss of inner hair cells in patients with sensorineural hearing loss. Supported by NIH-NIDCD Grant P50 DC015857

Category: Diagnostic Audiology / Otology

Poster #: 017

Effect of Stimulus Type on Extended High Frequency Thresholds

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Objectives: Recent data suggest that extended high frequency information plays a significant role in speech understanding and localization; however, measurement protocols for these stimuli are not well established in the literature, particularly for children. In young adults, detection thresholds above 8 kHz can be highly variable. Furthermore, there is an effect of stimulus type on detection thresholds for frequencies greater than 4 kHz, particularly extended high frequencies through 16kHz. The purpose of this study was to further evaluate the effects of three stimulus types - pure tones, pulsed tones, and warble tones - on detection thresholds at 8, 11.2, and 16 kHz for adults, and at 8 and 16 kHz for school-age children. We expected to see an increase in variability among thresholds as a function of stimulus frequency, particularly for young children. The long-term goal of this study is to inform clinical assessment of extended high-frequency sensitivity in young children.

Design: Participants were adults (19-45 years) with normal hearing 250-8000 Hz, bilaterally. Recruitment and testing in children with normal hearing age 5-13 years is ongoing. Extended high frequency detection thresholds were determined at 8, 11.2, and 16 kHz in a single ear using the standard Hughson-Westlake procedure with a 5-dB step size followed by obtaining thresholds using 1-dB step sizes. Thresholds were established for pure tone, pulsed tones, and warble tones for all three frequencies. Test ear was counterbalanced; frequency and stimulus type were randomized.

Results: Data collection is ongoing; reported results are for 13 adult listeners. Differences in threshold measured with the three stimuli increased as a function of test frequency. Thresholds were consistent across stimulus types at 8 kHz. Effects of stimulus type were modest at 11.2 kHz and substantially larger at 16 kHz. For some participants, thresholds at 16 kHz were considerably better for warble tones compared to thresholds obtained for pure tones or pulsed tones.

Conclusions: Consistent with published data, results indicate that stimulus type can have a significant effect on threshold estimates for adults tested at extended high frequencies, particularly when warble tones are used to test 16 kHz. Better thresholds for warble tone stimuli could be due to increased audibility at the lower edge of the frequency excursion, an effect that would be most pronounced for listeners with steeply sloping hearing losses. Additional effects related to perceptual salience of dynamic stimuli are expected for children.

Category: Diagnostic Audiology / Otology

Poster #: 018

Effects of Acoustic Leaks and Ear-Tip Loosening on Absorbance Measurements

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Objectives: Power absorbance, a wideband acoustic immittance (WAI) measure, is sensitive to pathological changes in the middle ear. Loose probe fitting in the ear canal and acoustic leaks result in artificially increased absorbance. Previously, researchers have quantified the effects of acoustic leaks and determined criteria based on WAI measures to predict leak-related changes (Δ -absorbance), while others simply relied on tympanometric pressurization as assurance of a hermetic seal. This work investigates acoustic leaks and their relationship to ear-canal pressurization using a clinical WAI system. Specific objectives were to: (1) assess the effect of microscopic holes in ear tips on absorbance, impedance phase ($\angle Z$), and pressurization variables (maximum-achieved pressure and leak resistance), (2) assess whether low-frequency absorbance, $\angle Z$, and pressurization variables predict Δ -absorbance, and (3) determine whether ear-tip loosening produces similar findings to experimentally controlled leaks.

Design: Twenty normal-hearing adults underwent repeated WAI and ear-canal-pressurization tests (swept from 0 to -400 daPa). In each participant, testing was conducted using a leak-control procedure, and an ear-tip-loosening procedure: In one ear, measurements were repeated using modified rubber probe tips with microscopic holes (diameters= 0.5, 0.8, 1.0, 1.2, and 1.5 mm), and an un-modified (no-leak) condition. In the opposite ear, measurements were repeated with progressive probe pulling, called ear-tip-loosening, to replicate how acoustic leaks occur in clinical settings. Separate repeated-measure ANOVA analyses evaluated the effect of acoustic leaks on each of absorbance, $\angle Z$, and the two pressurization variables. In the leak-control data, Δ -absorbance values were computed as the differences between absorbance in the no-leak condition and each leak size. Correlation and best-fit analyses evaluated the relationships between Δ -absorbance and each low-frequency absorbance, $\angle Z$, and pressurization variables. In the ear-tip-loosening data, Δ -absorbance values were computed as the differences between the measurement with maximum pressure of -400 daPa (no-leak) and each successive measurement. Finally, modeled relationships from leak-control data were validated using ear-tip-loosening data.

Results: The effect of leak size was significant and exhibited the following patterns for all tested measures: All leak sizes resulted in significant differences from the no-leak condition. Recordings using the 0.5-, 0.8-, 1.0-mm leaks differed from each other and from recordings using 1.2- and 1.5-mm leaks, which were not statistically different. In the leak-control data, Δ -absorbance exhibited a linear relationship with low-frequency absorbance ($R^2 \approx 0.88$), a quadratic relationship with low-frequency $\angle Z$ ($R^2 \approx 0.84$), and with max-pressure and leak resistance ($R^2 \approx 0.47$). Pressurization measures predicted Δ -absorbance for small leak sizes (<0.1 mm), otherwise no pressurization was possible. Models derived from fitting the above relationships in the leak-control data predicted the relationship patterns in the ear-tip-loosening data with good accuracy.

Conclusions: Acoustic leaks of increasing sizes resulted in increased low-frequency absorbance and $\angle Z$. Both WAI measures were predictive of leak-related changes, consistent with previous reports. The findings demonstrate that the ability to pressurize the ear canal is predictive of leak-related absorbance changes for small leak sizes. Conversely, the inability to pressurize the ear canal indicates acoustic leaks >1.0 mm in diameter. Finally, models for leak prediction in experimental data were generalizable to leaks that occur with loose ear-tip fitting.

Category: Diagnostic Audiology / Otology

Poster #: 019

Speech intelligibility deficits in Sensorineural Hearing Loss of Differing Etiologies

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Objectives: This retrospective study of a large audiometric database compares the discrepancies between measured and predicted word-recognition scores in patients with sensorineural hearing loss of several etiologies to gain insight into which conditions are likely associated with most cochlear neural degeneration.

Design: We collected audiological data from patients with 1) a history of recreational/occupational noise exposure (n=397) or presenting with an audiometric 4-kHz notch (n=1,517); 2) a history of exposure to ototoxic drugs including carboplatin or cisplatin (n=150 ears), vancomycin (n=32 ears) or gentamicin (n=42); 3) diagnosed with a neuropathy including vestibular schwannoma (n=664 ears) or neurofibromatosis of type II (n=282 ears); 4) diagnosed with sudden sensorineural hearing loss (n=156 ears); and 5) diagnosed with Meniere's disease (n=128 ears that received gentamicin and n=628 ears that did not). Data were compared to a control cohort of patients with sensorineural hearing loss (n=44,967) and no known otologic disease, disorder or condition other than aging. Speech recognition performance was assessed using CNC word lists presented with a contralateral masker. The Articulation Index (AI) was used to predict the speech intelligibility curve (SIC) using a transfer function for CID W-22. The level at which maximal intelligibility was predicted was chosen as presentation level (no less than 70 dB HL). Suprathreshold speech intelligibility deficits were assessed by comparing measured with predicted (as inferred by the SIC) word recognition scores.

Results: Patients with Meniere's disease, vestibular schwannoma, neurofibromatosis type II or sudden sensorineural hearing loss showed deficits in speech intelligibility that were dramatically larger than those from audiometrically matched controls with presbycusis only. In patients with a history of noise exposure or ototoxic drugs, word scores were also worse than in controls. While increased deficits in word recognition were expected from patients with explicit otologic neuropathies, the data suggest that cochlear neurons are a major, if not primary, target in several other otologic etiologies.

Conclusions: Assessment of word recognition deficits in a variety of otologic etiologies suggest that cochlear neurons may be a major target of these diseases. Supported by NIH-NIDCD Grant P50 DC015857

Category: Diagnostic Audiology / Otology

Poster #: 020

Effects of Substance Misuse on Auditory and Vestibular Function

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Objectives: Little is known about how substance misuse affects the auditory and vestibular systems. The goal of this project is to comprehensively evaluate hearing and vestibular function in adults who misuse illicit drugs, prescription opioids, and/or alcohol. The literature primarily consists of single-case reports noting sudden hearing loss following overdose, which may or may not recover. Most studies relied on patient report rather than audiometric data, and even fewer evaluated vestibular function. None tested hearing in the extended high-

frequency (EHF) range. It was hypothesized that individuals who chronically use substances (with or without experiencing overdose) would exhibit hearing loss in the EHF range, consistent with typical manifestations of ototoxicity. Furthermore, it was hypothesized that permanent central and/or peripheral vestibular damage would exist, with the severity likely influenced by substance type/duration.

Design: Participant inclusion criteria were adults 19-59 years of age with a history of chronic use of illicit drugs, prescription opioids, and/or alcohol. Our goal for this study is a minimum of 30 participants; we have completed a preliminary analysis for 19 participants and are actively collecting data. Participants completed a health- and use-history questionnaire, the Montreal Cognitive Screening Test (MoCA), tympanometry, standard and EHF pure-tone audiometry, EHF distortion-product otoacoustic emissions (DPOAEs), retrocochlear screening auditory brainstem response (ABR) testing, sentence recognition in noise using the BKB-SIN test, vestibular bedside, oculomotor testing, video head impulse testing (vHIT), cervical and ocular vestibular evoked myogenic potentials (cVEMP and oVEMP), clinical dynamic visual acuity (DVA), and a standing balance test.

Results: Results thus far indicate a high rate of poly-substance use, with methamphetamine being the substance most used. Mean MoCA scores were below the passing cutoff, with primary deficits on memory-related items. Audiometric thresholds in the standard and EHF ranges were, on average, 14 dB and 26 dB poorer, respectively, than a healthy comparison group. DPOAEs were consistent with the audiometric thresholds. ABR wave III and V amplitudes and latencies were consistent with published age-matched data. The mean speech understanding in noise was 0.8 dB SNR. Ocular motility results suggest central vestibular dysfunction in approximately 10-50% of participants. A higher absent VEMP response rate was observed (15%); however, when present, mean VEMP peak-to-peak amplitude results were comparable to adult normative data as well as mean vHIT gain, reflecting normal high-frequency otolith and semicircular canal function, respectively.

Conclusions: Results to date suggest mild cochlear hearing loss that is worse in the EHF range than in the standard range, and central vestibular dysfunction and imbalance. Given the reduced cognitive test results and the link between hearing loss and cognitive decline, the present results have implications for including questions about substance misuse in the case history, more frequent monitoring, and more aggressive management of hearing loss. Similarly, central vestibular dysfunction increases the risk of falls, injuries, and poorer physical activity in adults who misuse substances. These results suggest consideration for implementing vestibular/balance screenings and accessible interventions in this vulnerable population. Future analyses will address potential differential effects on hearing and balance by substance type, duration, and other health factors.

ELECTROPHYSIOLOGIC RESPONSES

Category: Electrophysiologic Responses

Poster #: 021

A Novel Approach to Measure Speech-Derived ABR by In-Ear TipTrode

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Objectives: The auditory brainstem response (ABR) is a powerful measurement to assess hearing condition objectively and passively. The neural responses to the sound stimuli can be averaged to reveal the ABR

waveform that consists of Waves I - V, each is associated with a different subcortical structure along the auditory pathway and can be used to estimate audiograms for individuals. Although ABR is typically recorded from the scalp electrode placed at Cz, earlier research has found higher SNR, especially for the earlier ABR wave such as Wave I, by placing electrodes in the ear canals. Based on these studies, the ABR measurement setup could be further simplified, while maintaining similar or even higher signal quality with a type of specialized electrode -- the TipTrode (Etymotic Research, Elk Grove, IL). However, little research has been done to compare ABR recorded from TipTrode and Cz. Moreover, instead of using more natural sound stimuli such as speech, previous studies only used TipTrododes to measure click-evoked ABRs. In this pilot study, we compared ABR morphology simultaneously recorded from Cz and TipTrode when subjects listened to both clicks and naturally uttered speech.

Design: Five subjects were recruited in this pilot study. EEG was recorded using the EP-Preamplifier specifically designed for recording ABRs (Brain Vision, Morrisville, NC). Multitrododes were placed at Cz (non-inverting), right mastoid (inverting reference), and the high forehead (ground). In addition, we customized the gold-foil of ER3-26A/B TipTrode cable to be compatible with the EP-Preamplifier system so that we could record Cz and TipTrode simultaneously. Data were sampled at 25 kHz and offline high-pass filtered between 100 and 3000 Hz for the click-evoked ABR and 150 and 2000 Hz for the speech-derived ABR using a first-order causal Butterworth filter. We collected click-evoked ABR from 3 subjects. A total of 13200 100- μ sec clicks (5 mins) at 76 dB peSPL were presented with alternating polarity to prevent stimulus artifacts. We collected speech-derived ABR from 2 subjects. Part of the audiobook *The Alchemyst* (Scott, 2007), read by a male narrator, was modified to be "peaky" and presented in 65 dB SPL to best elicit ABR.

Results: We acquired click-evoked ABR by averaging across click presentations. For the speech-derived ABR, we used linear least-squares regression to calculate the responses. The results showed a similar click-evoked ABR morphology between Cz and TipTrode for both subjects. Pearson correlation showed high correlation ($\rho > 0.7$ and $p < 0.000$) between the waveform measured from Cz and TipTrode for all subjects. We also observed ABR waveforms from continuous speech. The derived ABR showed more clear Wave I, III than Cz.

Conclusions: We showed a great potential of applying TipTrode to measure ABR from continuous speech by revealing clear earlier waves. Future research will replicate our pilot study with a larger and more diverse set of subjects. If successful, this approach may have great potential to apply in clinical measurements and products such as VR headsets and AR glasses.

Category: Electrophysiologic Responses

Poster #: 022

Suprathreshold Auditory Evoked Potential Measures Among Carboplatin-Treated Chinchillas

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Objectives: The audiogram is considered the gold standard measure of hearing health. However, several animal models have reliably shown that significant cochlear damage, such as the loss of inner hair cells (IHC), can go undetected by the audiogram if outer hair cells (OHC) remain. Our previous studies have shown little-to-no change in pure tone thresholds following selective IHC loss. In contrast, we found that suprathreshold auditory

brainstem response (ABR) wave-1 amplitudes were reduced, suggesting a reduction in cochlear output despite the absence of elevated thresholds. To date, reduced wave-1 amplitudes have been the hallmark sign of selective IHC or IHC synapse loss among pre-clinical lesion models. However, additional assays are needed as these animal data have yet to be supported by clinical studies. The auditory steady-state response (ASSR) has been suggested as a potential measure of selective cochlear lesions given it can assess the auditory system's ability to phase-lock to the stimulus envelope. In this study, we examined the relationship among ABR wave-1 amplitudes and ASSR response magnitudes following carboplatin-induced selective IHC loss in the chinchilla. We hypothesized that IHC loss would reduce both ABR wave-1 and ASSR amplitudes with ASSR showing a greater degree of sensitivity to loss of IHC as a function of amplitude modulation (AM) depth.

Design: Adult, free feeding, male and female chinchillas were used for this study. Sedated distortion product otoacoustic emissions (DPOAE) and ABR thresholds were obtained as a measure of overall hearing sensitivity and from subjects to confirm normal nonlinearity of the cochlea. Suprathreshold ABR wave-1 amplitudes were measured bilaterally at 90-, 80-, and 70-dB SPL with 1, 2, 4, 8, 12, and 16 kHz tone pips. ASSRs were elicited by AM tones presented in quiet with carrier frequencies of 1, 2, 4, and 8 kHz, modulated at 88 Hz, and modulation depths of 100% (deep AM), 40% (moderate AM), and 20% (shallow AM). Simultaneous ASSR response magnitudes were recorded bilaterally at suprathreshold intensities of 90-, 80-, and 70-dB SPL. All pre- and post-carboplatin DPOAE, ABR thresholds and amplitudes, and ASSR measures were obtained using a commercially available clinical system. Following baseline measures, animals were treated with a single dose of 75 mg/kg of carboplatin (i.p., by body weight), a dose reliably shown to produce 50-80% IHC loss with minimal OHC loss. Post-carboplatin assessments were performed three weeks following treatment to allow for recovery time.

Results: Carboplatin had no significant effect on DPOAE, suggesting survival and function of OHCs. ABR thresholds did not change significantly following carboplatin. ABR wave-1 amplitudes were substantially reduced, even in the absence of elevated thresholds. ASSR AM response magnitudes showed differences following carboplatin, specifically, magnitude and phase locking values for shallow AM tones were significantly reduced.

Conclusions: Findings support previous studies suggesting the use of suprathreshold ABR wave-1 and ASSR amplitudes as sensitive measure of IHC pathology. Research reported in this abstract was supported by the NIDCD of the National Institute of Health under award number R01DC014088.

Category: Electrophysiologic Responses

Poster #: 023

High-Frequency Auditory Brainstem Response in Extremely and Very Preterm Infants

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Objectives: Approximately 10% of preterm infants have permanent hearing loss or are at risk for delayed or progressive hearing loss. Current newborn hearing screening is insensitive to hearing loss less than 30-40 dB HL and higher frequency loss. These "minimal" losses are at least 3 times more prevalent than moderate/greater

loss and are related to poorer language outcomes. However, there is a lack of evidence supporting sensitized hearing measures capable of detecting these forms of hearing loss in infants.

Design: This longitudinal study aims to improve prediction of speech, language and pre-literacy deficits in extremely and very preterm infants (≤ 32 weeks gestational age). A total of 300 infants will be assessed from birth through 3 years of age with structural and resting state functional MRI, speech evoked response EEG, sensitized hearing measures, hearing milestone and speech-language assessments. In this preliminary analysis, 42 preterm infants born between 24-32 weeks gestational age were tested at 3 months corrected-to-term age (range=2-5 mos; male=27). Test procedures included hearing history, otoscopy, 1 kHz tympanometry and distortion product otoacoustic emissions (Titan, Interacoustics), and auditory brainstem response (ABR) using click (70 and 30 dB nHL) and level-specific CE-Chirp stimuli (1 and 8 kHz; Eclipse, Interacoustics). Bayesian weighting and multiple ABR stopping criteria were employed, including response confidence (FMP) and residual noise. Bone conduction thresholds were measured if 1 kHz air conduction thresholds were ≥ 20 dB nHL. Published normative latency ranges from full-term, well-baby infants were used for comparison.

Results: All infants had a detectable ABR to clicks at 70 dB nHL, however 46% (38 ears) had abnormal waveform morphology. Of these, wave I and/or wave III were absent in 18% (7 ears) and the latency was delayed in 82% (31 ears) while wave V latency was early in 32% (12 ears). Overall, 41% (17 infants) had hearing loss (11 bilateral, 6 unilateral). Tympanometry and bone conduction results indicated that 17% (7 infants) had conductive loss, 14% (6 infants) had sensorineural loss, 7% (3 infants) had mixed loss, and 2% (1 infant) was undetermined. At 1 kHz, 29% (24 ears) had thresholds ≥ 20 -25 dB nHL (varied due to age-based eHL correction factor; mean=34 dB nHL; range=25-70 dB). At 8 kHz, 20% (17 ears) had thresholds ≥ 20 dB nHL (mean=33 dB nHL; range=20-65 dB).

Conclusions: An unexpectedly high proportion of this sample had a sensorineural component to their hearing loss yet passed their UNHS. Nearly half had abnormal click ABR morphology, potentially due to hearing loss, brain injury, or delayed neuromaturation. These results are novel and clinically relevant as it is the first report of 8 kHz LS CE-Chirp stimuli in infants at risk for high-frequency hearing loss. Ongoing analysis includes comparison to hearing loss risk factors and relationships between ABR thresholds and DPOAEs. Updated results will be presented as infants continue to be enrolled. Results to date suggest that functionally important, permanent hearing loss is present in about 1 in 5 extremely and very premature infants.

Category: Electrophysiologic Responses

Poster #: 024

Evaluation of Additivity during Spectral Integration by the Medial-Olivocochlear Reflex

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Objectives: Medial olivocochlear reflex (MOCR) strength is strongest in response to wideband sound, implicating spectral integration of afferent activity within the MOCR neural circuit. Previous research suggests the integration process is additive in nature, at least on average. The objective of the present study was to evaluate the process of spectral integration by the MOCR for departures from additivity. We hypothesized that departure from additivity (i.e. interaction) occurs in cases of an especially weak or strong MOCR. Namely, negative interaction (i.e. loss during integration) was predicted in instances of a weak MOCR, whereas positive interaction (i.e. gain during integration) was predicted in instances of a strong MOCR.

Design: Thirty young, normal-hearing adults participated in the study. Transient-evoked otoacoustic emissions (TEOAEs) were used to assay the MOCR. TEOAEs were measured with and without noise presented to the contralateral ear. Noise conditions included (1) a 2.5-octave wide low-frequency narrowband noise, (2) a 2.5-octave wide high-frequency narrowband noise, and (3) simultaneous presentation of the low- and high-frequency narrowband noise. The latter condition is hereafter referred to as the wideband condition. For each condition, MOCR strength was quantified as the dB-change in the TEOAE between noise-on and noise-off states. The efferent response was calculated in 1-octave bands centered at 1, 2, and 4 kHz. For each TEOAE frequency band, a metric defined as MOCR gain was calculated as the dB-difference between the arithmetic sum of the MOCR strengths measured for the low-frequency and high-frequency narrowband noises, and the wideband MOCR strength. Zero gain corresponds to additivity, whereas positive and negative gain is associated with positive and negative interaction, respectively, between the narrowband noise activators. To determine if wideband MOCR strength was related to MOCR gain, a generalized linear model was analyzed that included wideband MOCR strength as the dependent variable, and MOCR gain and TEOAE frequency as predictors.

Results: For all TEOAE frequency bands, MOCR strength was highest for the wideband noise condition. MOCR strength measured in the 2- and 4-kHz TEOAE bands was similar for the low- and high-frequency narrowband noises. The MOCR response in the 1-kHz TEOAE band was larger for the low-frequency, compared to high-frequency noise. The average departure from additivity (MOCR gain) approximated +0.25 dB, at each TEOAE frequency. MOCR gain was a statistically significant predictor of wideband MOCR strength. Wideband MOCR strength increased with MOCR gain.

Conclusions: Efferent feedback at the level of the outer hair cells and mediated by the MOC neurons is driven by activation of broad cochlear regions. Findings suggest that integration of afferent activity within the MOCR circuit is not purely additive. Rather, at least for integration across relatively broad bandwidths, integration is characterized by a positive interaction over bandwidth. Moreover, a greater degree of positive interaction appears to contribute to a stronger wideband MOCR strength.

Category: Electrophysiologic Responses

Poster #: 025

Simultaneous Recording of Auditory Brainstem Responses at Clinical Discharge Level

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Objectives: The present study investigated Auditory Brainstem Response (ABR) wave V morphology changes as a consequence of recording multiple ABRs simultaneously compared with classic serial stimulus presentation.

Design: ABRs to Narrow Band CE-Chirps centered at .5, 1, 2 and 4 kHz were obtained at the clinical discharge level and 10 dB above. In both serial and simultaneous presentation each Narrow Band CE-Chirp was presented at a (nominal) rate of 40 Hz. ABRs were collected from 24 normal-hearing young adults (N = 48 ears) using the Interacoustics Eclipse system with Matlab controlled stimulus presentation and analysis.

Results: Wave V morphology of the ABRs collected in serial mode had the expected mean latency and amplitude for each NB CE-Chirp. In contrast, the simultaneously recorded ABRs demonstrated significantly longer wave V latency for the low frequency Narrow Band CE-Chirps compared with the serial presentation. Further, the high frequency Narrow Band CE-Chirp wave V amplitude decreased in the simultaneous presentation.

Conclusions: These findings suggest that a masking effect is introduced by the presence of the other stimuli when using simultaneous presentation and indicate that simultaneous presentation increases the ABR place specificity.

Category: Electrophysiologic Responses

Poster #: 026

Acoustic Reflex Measures in Carboplatin-Treated Chinchillas

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Objectives: The purpose of this study was to assess the effect of selective inner hair cell (IHC) loss on acoustic reflex (AR) thresholds in a chinchilla animal model. In humans and other species, the AR is characterized as a contraction of the middle ear stapedius muscle in response to moderately loud sound or vocalization. This reflexive response reduces acoustic input to the inner ear by decreasing the admittance of the tympanic membrane. The threshold at which the AR is present is often measured as part of a comprehensive audiological evaluation, as it provides information on the integrity of the middle ear, the inner ear, and the central auditory nervous system. In humans, mild to moderate sensorineural hearing loss (SNHL) has little effect on AR. Because mild to moderate SNHL primarily affect outer hair cells (OHC), the AR is thus believed to be driven, in large part, by inner hair cells (IHC). To test this hypothesis, we treated chinchillas with the anticancer drug, carboplatin, which selectively destroys IHC in this species and assessed AR thresholds before and after treatment. In previous studies, we found that ipsilateral AR amplitudes measured via a 226 Hz probe tone at a high intensity level (95 dB HL) remained unchanged or increased following IHC loss. As a follow up, this study aimed to assess whether AR thresholds were more sensitive to IHC loss and whether this measure could be used to detect IHC pathology.

Design: Free-feeding young adult chinchillas (3-4 years-of-age) housed in an enriched environment were used for this study. A Tymstar middle ear clinical analyzer was used to obtain ipsilateral and contralateral AR thresholds via 226 Hz probe tone in awake animals. AR thresholds were elicited using various pure tone stimuli (.5, 1, 2, and 4 kHz) and broadband noise (BBN). Distortion product otoacoustic emissions (DPOAEs) were measured as an assessment of OHC presence and function. Auditory brainstem response (ABR) thresholds were obtained at 1, 2, 4, 8 and 12 kHz as a measurement of auditory sensitivity. After obtaining baseline data, animals were treated with a 75 mg/kg dose of carboplatin (i.p.) to produce a moderate-severe IHC lesion (50-80% IHC loss) and little-to-no outer hair cell (OHC) loss. AR thresholds, DPOAEs, and ABR thresholds were re-assessed following a three-week recovery period.

Results: Consistent with our previous studies, carboplatin treatment induced 50-80% IHC loss and severe loss of afferents in surviving IHC, but did not affect OHC, DPOAEs or ABR thresholds. Data also suggest that IHC loss does not significantly elevate 226 Hz probe tone AR thresholds.

Conclusions: Based on the 226 Hz AR threshold data, we conclude that AR threshold is relatively insensitive to IHC pathology. Research reported in this abstract was supported by the NIDCD of the National Institute of Health under award number R01DC014088.

Category: Electrophysiologic Responses

Poster #: 027

Synchrony-Based Analysis of cVEMPs: Inter-Trial Coherence

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Objectives: Cervical vestibular evoked myogenic potentials (cVEMPs) are a common test to evaluate saccular function, and they can be recorded from the sternocleidomastoid muscle (SCM) when the muscle is contracted, such as when the head is turned. Since cVEMPs were initially reported, their analysis has focused on the latency and amplitude of their p1 and n1 peaks. However, other approaches to evoked potential analysis may be used to quantify other aspects of these responses. Inter-trial coherence is an analysis method used to represent neural synchrony, and while this measure has been applied often in auditory evoked potentials it does not appear to have been previously applied to cVEMPs. The purposes of the present study were 1) to characterize the time-frequency characteristics in young, healthy individuals, 2) to apply a time-frequency detection algorithm, and 3) to quantify cVEMP response energy using inter-trial coherence.

Design: Twenty young adults (mean age = 21, std. dev. = 1.9) with no history of vestibular lesions or middle-ear pathologies participated in this study. Stimuli were 500 Hz tonebursts (2-0-2 ms) delivered by a B81 bone-oscillator at 123 dB pSPL (90 dB nHL). Subjects monitored EMG activation by viewing a real-time bar graph and maintained average EMG activation of 50 μ V. Responses were analyzed in time-frequency space. First, Rayleigh p values for each time-frequency point were calculated to serve as an objective response detection algorithm. Second, inter-trial coherence was calculated to quantify synchrony; a value of 0.0 represents an absent response and a value of 1.0 represents perfect synchrony.

Results: Time-frequency characteristics of cVEMPs were established. The temporal and spectral locations of statistically-detected response energy were used to determine a time-frequency response region from which to quantify the inter-trial coherence values. Inter-trial coherence from the response region revealed highly synchronous response energy, with maximum ITC values averaging approximately 0.7 (std. dev. = 0.04). Conventional measures of p1 and n1 latency and amplitude were consistent with previous literature. Interaural asymmetry ratios were comparable between amplitude- and synchrony-based measures

Conclusions: Synchrony-based, time-frequency analyses were successfully applied to cVEMP data and revealed high degrees of synchrony in transient cVEMPs. This type of analysis may differentiate synchrony from amplitude in populations with disrupted neural synchrony and could also be used as a complementary analysis to conventional visual response detection. This work was supported, in part, by the American Academy of Audiology Foundation (D.R.).

Category: Electrophysiologic Responses

Poster #: 028

Envelope Following Response Correlates of Selective Inner Hair Cell Loss

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Objectives: Inner hair cell (IHC) pathology, such as deafferentation of IHC afferent nerve fibers, referred to as synaptopathy, or the complete loss of IHCs, has been speculated to contribute to functional auditory deficits such as poorer hearing-in-noise. However, suprathreshold outcomes are often not well correlated with hearing sensitivity, suggesting a need for additional diagnostic tools that are sensitive to various auditory lesions. Thus far, pre-clinical physiological studies measuring auditory brainstem response (ABR) outcomes after IHC pathology have shown little-to-no change in thresholds. Yet, ABR wave-I amplitudes are typically reduced at suprathreshold levels, suggesting a reduction in cochlear output despite an absence of elevated thresholds. Suprathreshold ABR wave-I amplitude reductions have been established as the hallmark of afferent synapse loss, but wave-I amplitudes are known to vary greatly across individuals, limiting their use as a physiological biomarker of IHC lesions among patients with auditory complaints without threshold elevations. The envelope following response (EFR) has been suggested as a potential assay that may be sensitive to IHC lesions. The EFR is a steady-state evoked potential that can assess the auditory system's ability to phase-lock to the stimulus envelope. For the current investigation, we evaluated the relationship among EFR magnitude-level functions before and after carboplatin-induced selective IHC loss in the chinchilla. We hypothesized that IHC loss would reduce EFR amplitudes and these response magnitudes would show a greater degree of sensitivity as a function of stimulus presentation rate and amplitude modulation (AM) depth.

Design: Free-feeding, young-adult chinchillas (1 - 3 years-of-age), were used to evaluate effects of selective IHC loss on suprathreshold EFR measures before and after carboplatin-treatment. Distortion product otoacoustic emissions (DPOAE) and ABR thresholds were obtained to assess the status of cochlear nonlinearity and as a measure of overall hearing sensitivity. Steady-state stimuli were presented with carrier frequencies of 1, 2, 4, and 8 kHz modulated around 88 Hz (fast-rate) or 50 Hz (slow-rate) across three AM depths, 100% (deep AM), 40% (moderate AM), and 20% (shallow AM). Simultaneous EFR response magnitudes were recorded for bilateral presentations at suprathreshold intensities of 90, 80, and 70 dB SPL for each experimental condition (rate and AM depth). Following baseline measures, animals were treated with a single dose of 75 mg/kg of the anticancer drug carboplatin, a dose known to reliably produce 50 - 80% IHC loss with little-to-no outer hair cell (OHC) loss. Post-carboplatin assessments were performed three weeks following treatment to allow for recovery time.

Results: As expected, carboplatin-treatment had no significant effect on ABR thresholds and DPAEs, suggesting survival and function of OHCs. EFR magnitude-level functions showed differences following carboplatin, even in the absence of elevated thresholds. Specifically, magnitude and phase locking values for shallow AM tones were significantly reduced.

Conclusions: Findings suggest that suprathreshold EFR measures may serve as a sensitive assay of selective IHC loss and could potentially be used clinically to better classify patient auditory deficits. Research reported in this abstract was supported by the NIDCD of the National Institute of Health under award number R01DC014088.

HEARING LOSS / REHABILITATION

Category: Hearing Loss / Rehabilitation

Poster #: 029

Did the COVID-19 Pandemic Delay Hearing Care Among Older Adults?

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Objectives: The ongoing COVID-19 pandemic is still causing havoc in global health. Because of public health restrictions enacted to limit virus spread, many have postponed all but the most essential healthcare needs. It is especially concerning for older adults, who are more likely to have multiple chronic conditions concurrently. We hypothesized the pandemic caused a wide delay among older adults in seeking diagnosis and treatment for hearing loss (HL).

Design: For this cross-sectional study, we used data from the National Health and Aging Trends Study (NHATS), a nationally representative survey of Medicare beneficiaries. HL was determined based on the validated answers to the sensory impairment questions in the survey. A supplemental COVID-19 survey was mailed to the participants from June to October 2020. By January 2021, 3,257 participants (aged ≥ 70 yrs) had returned completed COVID-19 questionnaires, with the majority having been self-administered between July and August 2020. The question "What type(s) of care did you put off?" was selected to evaluate how healthcare needs were delayed because of COVID-19. We used Rao-Scott chi-square statistics and multivariable logistic regressions to determine factors associated with delayed healthcare among older adults with and without HL. Sampling weights were applied to account for the complex survey design.

Results: The participants in the study represented 32.7 million older adults in the US. At the time of filling out the questionnaire, 4.3% reported experiencing COVID-19 symptoms, 2.4% reported having positive COVID-19 test results, and 92.7% reported that the COVID-19 was still affecting their lives. The weighted prevalence of HL was 29.3% and 19.9% were hearing aid users. There were no differences in access to healthcare between participants with and without HL, with 95.9% reporting that they had a regular source. We estimated that over 12.4 million older adults, or 38% [95% confidence intervals (CI) = 35.7 - 40.4%], put off needed or planned medical care during COVID-19. "Provider canceled, closed, or rescheduled" was the most common cause for delayed healthcare needs. Of those who deferred healthcare, 8.5% delayed hearing care. After adjusting for sex, race/ethnicity, marital status, or income, those with HL were six times more likely to postpone hearing appointments than those without HL (95% CI = 3.2 - 11.1); Over 90-year-olds were more likely to delay hearing care than those aged 70 to 74 [odds ratio (OR) = 2.9; 95% CI = 1.1 - 7.8]; people with higher education were three times more likely to delay hearing appointments than those with only primary or secondary education (95% CI = 1.5 - 4.4); participants with three or more comorbidities were more likely than those without comorbidity to put off hearing care (OR = 8.1; 95% CI = 1.3 - 50.7).

Conclusions: The COVID-19 pandemic had a detrimental impact on the healthcare needs of a substantial proportion of the older US adult population. Those with HL were no exception, with a six-fold higher likelihood

of delaying hearing care than those without HL. Innovative healthcare delivery systems are critical for meeting unmet needs.

Category: Hearing Loss / Rehabilitation

Poster #: 030

Adult Severe to Profound Hearing Loss: Where is the Evidence?

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Objectives: An estimated 87 million people worldwide have severe and profound hearing loss. Evidence shows that for the appropriate candidates, there are large, life-changing benefits from cochlear implants, the magnitude of which cannot be achieved using hearing aid technology alone. Despite this, only around 7% of adults in the U.S. and the UK, with qualifying hearing loss go on to receive a cochlear implant. That means that a large majority of adults with severe and profound hearing loss will continue to use hearing aids for the foreseeable future. Despite this the evidence which underpins best practice for these adults is weak. To address the problem of best practice for hearing aids and severe and profound hearing loss, a group of international experts have come together to develop practical guidelines.

Design: Best practice was defined using a two-stage approach: (1) use evidence where available, and elsewhere (2) provide the consensus advice of the expert panel. Where evidence is available it will provide the foundation for evidence-based practice and where the scientific evidence is insufficient, the guide provides specific recommendations based on expert advice. The authors hope that sharing this information will inform best practice in hearing care and improve outcomes for adults with severe and profound hearing loss. The aim was to develop practical guidelines based on existing evidence and not a systematic review.

Results: The results were 153 recommendations for best practice based on current evidence. These recommendations address management from audiological assessment and psychosocial needs to selecting hearing aids and wireless microphones and onwards to referral for cochlear implant. The relevance of other implantable technologies is also discussed. The recommendations highlight when onwards referral for specialist care by otologist, psychologist or other rehabilitation is indicated and the special considerations needed in tinnitus management. It closes with a discussion of the challenge of outcome measurement for this group and how to approach long term ongoing care. The results are published in Turton, L., Souza, P., Thibodeau, L., Hickson, L., Gifford, R., Bird, J., Stropahl, M., Gailey, L., Fulton, B., Scarinci, N., Ekberg, K., & Timmer, B. (2020). Guidelines for best practice in the audiological management of adults with severe and profound hearing loss. *Seminars in Hearing*, 41(3), 141-245. <https://doi.org/10.1055/s-0040-1714744>

Conclusions: The authors concluded that there are unique needs and special considerations for best practice in the audiological management of clients with severe and profound hearing loss. In developing best practice guidelines, the authors have highlighted the need for stronger research and identified gaps in the evidence. The guidelines give audiologists practical recommendations that can be immediately implemented in their practice. These recommendations have the potential to improve audiological outcomes and quality of life for adults with severe and profound hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 031

Defining Client-Centred Outcomes to Demonstrate Success of Hearing Rehabilitation in the Hearing Services Program

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Objectives: To date, there has been no consensus about which outcome measures should be used, how and when. Furthermore, most existing outcome measures have been developed without the involvement of consumers of hearing care. The principles of experience-based co-design suggest that health services, policymakers, and researchers should come together with clients to define what metrics should be used for their success. This study aimed to obtain a consensus on what outcome domains best reflect successful hearing rehabilitation according to both Professionals who provide hearing care and Consumers of hearing services.

Design: Two online Delphi processes were undertaken, one among Professionals involved in hearing services and one among Consumers of hearing services. In the first round, participants were asked to describe potentially relevant and important outcome domains for the assessment of hearing rehabilitation. In two subsequent rounds, respondents were asked to rate the importance of statements in relation to outcomes of successful hearing rehabilitation. The most important domains from both the professionals and the consumers were combined, and a consensus workshop of professionals and patient advocates agreed on the top four domains.

Results: Two sets of important outcome domains of hearing rehabilitation were developed. The outcome domains focused strongly on psychosocial outcomes of hearing services, rather than popularly used metrics such as use of devices and satisfaction with services. The top four ranked domains were: communication ability, personal relationships, and well-being, and social participation. In addition, there was consensus that an independent body develop and monitor a national outcomes database.

Conclusions: There was a strong recognition of the broader impacts of hearing difficulties, including impacts on family, social and community life. Many outcome domains do not have established and validated outcome measures that directly target these domains, and development of relevant outcome measures is required.

Category: Hearing Loss / Rehabilitation

Poster #: 032

Hearing Loss and Physical Activity: A Systematic Review

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Objectives: Age related hearing loss has been found to be associated with increased prevalence of chronic health conditions such as hypertension, diabetes, and cardiovascular disease. Modifiable risk factors for these conditions, including obesity, diet, and physical inactivity, have also been shown to be associated with hearing

loss. Further, adults with a hearing impairment appear to be less active than their normal hearing peers, suggesting that low levels of physical activity contribute to age related hearing loss, though more evidence is needed. The purpose of this investigation was to systematically identify, assess, and analyze the relevant literature regarding the relationship between hearing loss and physical activity among older adults, and whether hearing instrument use affects physical activity among older adults.

Design: The search focused on literature retrieved from PubMed, available in English. Time frame of publication was not restricted to allow for an exploratory search. The abstracts of the 232 articles resulting from the PubMed search were screened to identify those involving outcomes measures and study populations relevant to the research questions. Of these, 66 full text articles were reviewed and evaluated to determine the adequacy of the study design, statistical analyses, and follow-up, in the context of the specific research questions. A total of 20 articles relevant to either or both of the research questions were included in the final analysis.

Results: This comprehensive review revealed preliminary evidence that in older adults, hearing loss may be associated with reduced levels of physical activity. Further findings suggest that hearing loss may also be associated with limitations in physical mobility, and limitations in conducting activities of daily living (e.g. walking, climbing stairs). Other evidence resulting from this review indicates a relationship between hearing loss and poorer cardiovascular health outcomes. Lastly, limited but recent studies indicate a possible protective effect of hearing instrument use against physical inactivity and mobility limitations in older adults with hearing loss.

Conclusions: Incidence and severity of hearing loss does appear to be associated with physical activity, though it is not clear if this relationship is direct or indirect. A subsequent systematic literature search was planned to investigate the relationship between hearing loss and cardiovascular risk factors. Additionally, more evidence is needed to assess the impact of hearing instrument use on physical activity in older adults.

Category: Hearing Loss / Rehabilitation

Poster #: 033

Early Retirement and Sensory Impairments: the Modifying Effect of Wealth

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Objectives: Sensory impairments, hearing (HI) and vision (VL), are common among older adults. The relationship between impairing health conditions, individual wealth, and early retirement have been documented. However, the particular association with sensory impairments, which might impact labor productivity, and how this association might differ by people's wealth remains unexplored.

Design: Cross-sectional observational study. Using data from the Health and Retirement Study (HRS), we identified all adults who reported being in the labor force in 2004 (N=6,500). We excluded from our study sample all adults younger than 50, and older than 63 years old, with a limiting condition other than hearing or vision, without a full set of covariates, and who reported leaving the labor force for a reason other than retirement. Yielding a total of N=4,777 older adults. Using self-reported retirement information from 2004 to 2018, we identified all adults that retired before age 65. Based on baseline participant's self-reported measures of hearing and vision we created four sensory loss categories: no impairment, HI only, VI only, and Dual

Sensory Impairment (DSI). We estimated the association between sensory impairments and the probability of early retirement using a logistic regression model adjusting for baseline participant's age, sex, race/ethnicity, health, education, marital status, chronic conditions and non-housing financial wealth.

Results: Among 4,77 adults ages 50-63, 1,670 retired before age 65, and 3,107, retired after. In fully adjusted logistic regression models, when compared to people with no impairments, older adults with HI (Odds ratio (OR) = 1.48; 95% confidence interval (CI): 1.13,1.93) and DSI (OR=1.42; 95% CI: 0.95,2.12) were at higher odds of early retirement, however for the case of DSI, the CI includes the null hypothesis. Based on non-housing wealth, we stratified our analyses by wealth (below and above the population median). Among wealthier older adults, we estimated that individuals with HI had higher odds of early retirement (OR=1.40; 95% CI: 0.98,2.02), however the CI crosses the null. We found no statistically significant differences in the odds of early retirement among participants with VS, DSI, and those with no impairment. Among lower wealth older adults, we found that when compared to people with no impairments, older adults with HI (OR = 1.57; 95% CI: 1.05,2.34) and DSI (OR=1.91; 95% CI: 1.18,3.08) were at higher odds of early retirement.

Conclusions: In sample of older adults, we provide evidence that the presence of hearing impairments is associated early retirement. Given that in most cases, early retirement is accompanied by lower benefits during old age, non-invasive interventions addressing HI, such as the use of hearing aids might extend the permanence of older adults in the labor force. In addition, our results suggest that wealth modifies the associations between sensory impairments and early retirement, highlighting potential wealth disparities among people with sensory impairments.

Category: Hearing Loss / Rehabilitation

Poster #: 034

Sudden Hearing Loss Recovery: When Is Too Late To Intervene

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Objectives: The aim of this study was to evaluate recovery in hearing acuity of idiopathic sudden sensorineural hearing loss (SSNHL) based on timing of onset to determine how late is too late toThis study hypothesizes prognosis for recovery is poor when treatment is sought beyond 42 days of symptom onset while likelihood of recovery is high the sooner treatment is administered closer to timing of onset.

Design: A retrospective chart review was conducted once patient medical records were extracted from the medical record system from Thomas Jefferson University Hospital patients' seeking treatment for SSNHL from the department of otolaryngology between 2014-2019. SSNHL was indicated as primary and secondary diagnosis across 5 sites part of TJUH (Greater Philadelphia area) using ICD-9 and ICD-10 diagnosis codes. 2,313 cases were successfully extracted: once duplicates were removed, a total of 696 patient encounters were evaluated to determine which met the study inclusion criteria. 161 of the 696 total cases were included and analyzed based on timing of symptoms onset to treatment administration date, associated symptoms, age, gender, associated ear as well as recovery type: pure tone average and word recognition scores. Included participants were further divided into four groups representing the specific timing of onset. Group 1 was defined as those seeking treatment within 14 days. Group 2 was defined as those seeking treatment between 15-28 days

of onset. Group 3 was defined as those seeking treatment with 29-42 days of onset, and group 4 was defined as those seeking treatment >42 days of onset.

Results: Of the 161 included participants, 66 experienced recovery in PTA, WRS or a variation of both. While age, gender, and mode of treatment held no statistical significance to recovery, timing of onset to date of service, associated symptoms and recovery detail (PTA vs. WRS vs. WRS; PTA) was statistically significant.

Conclusions: Clinical practice guidelines published with the American Academy of Otolaryngology (AAO): Head and Neck Surgery (2019) caution low prognosis for recovery for treatment of SSNHL after 42 days (>6 weeks) as recovery expectation is low. This study discovered that while only 12.1% (8 of the 66 recovered participants) waited more than 42 days to seek treatment, recovery in WRS occurred. The hypothesis was proved incorrect, however, that benefit could not be anticipated in those seeking treatment beyond the clinical practice guidelines established by the AAO of more than 42 days of symptoms onset to initiation of treatment. Word recognition scores are critical prognostic indicators for determining success and realistic expectations with hearing aid use. They can also serve as a guide for audiologists in determining appropriate rehabilitative recommendations. The results of this study offers further clinical insights into recovery details the further out treatment is initiated compared to onset of initial symptoms.

Category: Hearing Loss / Rehabilitation

Poster #: 035

Decision-Making Factors Impacting Sound Acceptability Judgements by Young Typical Hearers

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Objectives: Standard audiological evaluations help determine if a person is a candidate for amplification; however, they do not determine how a person will acclimatize and accept amplified sound. Hearing-aid wearers often report aversiveness to amplified sound though not always related to loudness. Sound acceptability encompasses a holistic view of sound acceptance, including factors such as annoyance, aversiveness, and pleasantness. However, evaluating which factors listeners consider when rating sound acceptability has not been researched. Understanding the factors involved in how an individual is determining the acceptability of everyday sounds can help clinicians program an individual's hearing aids or provide more specific counseling to hearing aid wearers. The current research aims to evaluate the factors that listeners consider when determining sound acceptability and will provide insight into these factors.

Design: 53 normal-hearing young-adults participated in this descriptive study (M age=22.36 years; 39 female). Participants completed an online survey that included demographics questions, the International Mini-Markers personality test, the PERTH Emotional Reactivity Scale, the Digital-Sound Acceptability Test (D-SAT), and a comparison listening task using clips from the D-SAT. Multi-dimensional scaling (MDS) analysis was used to explore overall similarities of participants' acceptability comparison ratings of 9 everyday sounds. MDS plots of sound ratings were evaluated for trends based on the acoustic characteristics of the sounds and participant factors. Regressions evaluated how participants' ratings of full D-SAT sounds and how participant demographics were related to the MDS dimensions.

Results: MDS analysis resulted in two distinct dimensions that impacted participants' sound ratings. MDS plots were examined for general trends in each dimension. The first dimension had two clearly-defined participant clusters. Loudness appeared to play a role in this dimension, particularly when participants were making decisions for soft ($p=.01$) and possibly loud sounds ($p=.08$). Further supporting this interpretation, some of the first-dimension score variance was explained by ratings of soft ($r^2=.08$) and loud ($r^2=.12$) sounds. The second dimension was less clear, with no clear trends indicated in the MDS plots. To further evaluate second-dimension factors, groups of participants were formed from those with the highest and lowest individual weights for the second dimension. These participants' demographics, personality traits, and emotionality were compared. Post-hoc t-tests suggest that differences between these two groups include age ($p=.01$), emotionality ($p=.04$), and the sound spectrum ($p=.04$). Some of the dimension score variance was explained by age ($r^2=.03$), positive emotionality ($r^2=.08$), and episodic sound ratings ($r^2=.12$).

Conclusions: MDS analysis results suggest that these participants rated everyday sound comparisons based on several factors. The most salient dimension of their decision-making is related to loudness. The second dimension is likely related to the spectrum of the sound and may be influenced by age or emotionality of the person. However, normal-hearing young adults comprised this participant group, and it is unclear if these are the same dimensions that hearing aid wearers use when making sound acceptability decisions. Future research expanding the age range and hearing abilities of the participant group may provide more insight into how aging, hearing loss, and acoustic characteristics of amplified sounds might impact sound acceptability.

Category: Hearing Loss / Rehabilitation

Poster #: 036

Adapting Social Epidemiologic Frameworks for Promoting Hearing Health Equity

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Objectives: There is an increasing recognition of a greater need to support hearing health over the life course as a public health priority to promote healthy aging. Concurrently, there is also a growing understanding of persistent hearing health inequities at the individual, community, national, and global levels. Social, demographic, environmental, geographic, and historical influences affect hearing-related outcomes, though these factors are often unmeasured within traditional biological, clinical, and epidemiologic studies of hearing health. Public health disciplines such as social epidemiology can provide valuable frameworks for guiding initiatives in research, clinical practice, and policy reforms that address population disparities.

Design: In this review, we introduce the discipline of social epidemiology and its associated concepts framed within the contexts of hearing health and hearing care.

Results: Hearing health is inextricably linked to factors beyond biology. With a more holistic focus on integrating the biological and functional factors with the social and structural ones influencing health, social epidemiology offers key concepts and approaches for filling existing research and practice gaps.

Conclusions: We share some recommendations for researchers, clinicians, and clinical educators on how to begin integrating social epidemiologic principles into respective works to inspire greater cross-disciplinary collaborations and innovative research programs for the goal of advancing hearing health equity.

Category: Hearing Loss / Rehabilitation

Poster #: 037

Dual Sensory Impairment and Subjective Cognitive Complaints among Older Adults

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Objectives: Subjective cognitive complaints (SCC) are associated with poor quality of life, important for clinical care planning and management, and may predict dementia diagnosis. Dual sensory impairment (DSI) is a risk factor for dementia, but whether DSI is associated with SCC is unknown. We therefore evaluated whether self-reported DSI is associated with SCC.

Design: We performed a cross-sectional analysis of 9,899 community-dwelling respondents aged 60+ years without a history of dementia or depression in the 2019 National Health Interview Survey. Participants self-reported difficulty remembering or concentrating, seeing even when wearing corrective lenses, and hearing even when using a hearing aid. We defined SCC and sensory impairment for each mode as reporting at least some difficulty. We categorized sensory impairment into no sensory impairment, vision impairment (VI) only, hearing impairment (HI) only and DSI. We then estimated weighted prevalence ratios (PR) of SCC by impairment category.

Results: After weighting (9,899 participants representing a weighted $n = 59,261,749$), 12% of participants reported VI only, 19% reported HI only, and 7% reported DSI. Relative to no impairment, after adjustment for potential confounders, VI (PR = 2.07; 95% CI 1.79, 2.39), HI (PR = 2.26; 95% CI 2.00, 2.55), and DSI (PR = 3.21; 95% CI 2.83, 3.63) were associated with an increased prevalence of SCC.

Conclusions: In this nationally representative survey of older Americans, DSI was associated with a 3-fold increased prevalence of SCC. Although cross-sectional, these data underscore the importance of assessing multiple impairments as exposures when studying subjective cognition in older adults.

Category: Hearing Loss / Rehabilitation

Views of Aging: Associations between Self-report and Behavioral Hearing Measures

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Objectives: In this study, we analyzed associations between three self-report measures and two behavioral measures of hearing. We also explored to what extent self-reported hearing can be explained by behavioral measures and the following additional variables: negative views of aging, hearing-related negative attitudes, hearing-related stigma, and readiness for hearing intervention.

Design: Participants were 166 older adults (Mean = 71.5 years old, SD = 5.99) recruited from the local community. All participants completed the following measures: 1. Two behavioral measures of hearing abilities: pure-tone audiometry and the Canadian Digit Triplet Test (CDTT); 2. self-reported hearing-related measures: the Hearing Handicap Inventory for the Elderly (HHIE) and the Speech Spatial and Qualities of Hearing Scale (SSQ); 3. hearing-related questionnaires about attitudes and stigma: Attitudes towards Loss of Hearing Questionnaire (ALHQ), hearing-related stigma (subset of ALHQ), University of Rhode Island Change Assessment (URICA) adapted for hearing; and 4. questionnaires about Negative Views of Aging (NVOA), including Age-Related Awareness of Changes - Losses (AARC-L), Age-Based Rejection Sensitivity (ABRS), Age Stigma Consciousness (ASC) and Fear of Aging (FOA). All of the questionnaires were administered at one time point, while the behavioral measures of hearing were collected at an earlier appointment.

Results: Better-ear pure-tone average (PTA) thresholds for 500, 1000, 2000, and 4000 Hz were calculated (Mean = 21.7 dB HL, SD = 13.3; 67% had PTA < 25 dB HL). The CDTT Speech Reception Threshold (SRT) in noise was determined (Mean = -9.3 dB SNR, SD = 2.62). PTA and CDTT SRT were highly correlated ($r = 0.72$). SSQ and HHIE were also moderately-to-largely correlated with one another ($r = -0.59$). Weaker associations were found for correlations between the self-report and behavioral measures. SSQ was only weakly-to-moderately correlated with PTA ($r = -0.44$) and CDTT ($r = -0.46$), while HHIE were moderately-to-largely correlated with both PTA and CDTT (respectively, $r = 0.58$ and $r = -0.5$). Behavioral measures alone explained 23% of SSQ and 34% of HHIE. Including NVOA in addition to behavioral measures significantly improved the fit of all three models by approximately 5% each. Among the four components of NVOA, regression models identified significant and consistent contributions from the FOA measure. The significant contribution of NVOA was also confirmed by using residual analysis: after regressing behavioral measures of hearing on self-report measures, the residuals of such models could be significantly explained by NVOA. Simple path analysis identified significant indirect effects from behavioral to self-reported measures of hearing through NVOA, and such indirect effects were stronger for HHIE than SSQ. Hearing-related attitudes, stigma or readiness for intervention did not significantly explain the associations between self-reported and behavioral measures of hearing.

Conclusions: This study confirms significant associations between self-reported and behavioral measures of hearing. It also highlights the important associations between self-ageism (NVOA), especially its component FOA, and self-perceptions of hearing disability by older adults. Interventions to reduce self-ageism offer new promise for addressing hearing disability.

Poster #: 039

Development of a Novel Speech-in-Noise Test of Hearing

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Objectives: Some individuals experience hearing difficulties that are not explained by results on a standardized audiogram. A novel test of hearing that is both sensitive to hearing loss and independent of audiological thresholds is being developed. The test uses speech in noise rather than pure tones. The predictive capabilities and clinical feasibility of the test are being examined.

Design: Adult listeners with normal hearing and sensorineural hearing loss participated in the study. Participants were separated into four hearing-loss categories based on pure-tone-average of 1, 2, and 4 kHz thresholds. Speech-shaped noise was added to vowel-consonant-vowel (VCV) tokens. Signal-to-noise ratios (SNRs) that were estimated for each VCV token in a previous study to produce 90 percent correct recognition in a sample of normal hearing listeners were used in the present study. Optimal vowel-consonant combinations and SNRs were selected that best separated normal-hearing and hearing-impaired listeners in the current study based on area under the curve (AUC). Consonant-confusion matrices (CCMs) with 110 cells were reduced to 22 features by principal component analysis. Classifications were based on multinomial logistic regressions.

Results: Two-category classifications of hearing (normal vs. impaired) and sex (males vs. females) both resulted in AUC performance close to 1.00. Pure-tone-average predictions were based on expected values across 12 hearing-loss categories and produced an average error less than 2 dB.

Conclusions: This new, speech-in-noise test utilizing one signal-to-noise ratio for a single vowel and ten consonants could be administered in a clinical setting in just a few minutes. In addition to predicting classification of hearing and sex, other predictions, such as word recognition, may be of future interest. Undesirable overfitting of the data may be avoided by incorporating regularization into the logistic regression.

Category: Hearing Loss / Rehabilitation

Poster #: 040

Chatting with Roger

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Objectives: Conversing in noise may result in mental fatigue, communicative disengagement, and decreased physical and emotional well-being. Phonak Roger is a remote microphone system wirelessly connected to hearing aids (HAs) that can increase SNR. It assists with listening in challenging situations where there is

background noise and/or extended distance from the sound source (e.g., group activities, restaurant, lectures). This study evaluated the effects of using Roger on listener experiences during group conversations in noise.

Design: Four sets of 4 older adults (65-80 (average 71.5) years old; 8 male), who had mild to severe hearing loss and difficulties hearing in noise (LiSN-S PGA results within the yellow (4) or red (12) categories), engaged in casual conversations carried out in 4 different conditions (Roger on/off x facial mask on/off). Participants sat in a circle, at least 2 m from each other. They were fitted with Phonak Marvel HAs, each connected to one of two Roger Table Mic IIs. They filled out a conversation experience questionnaire (11 questions; 5-point response scale) after each condition, followed by a final focus group discussion with another questionnaire on listening condition preference.

Results: "Two-way repeated measures ANOVAs were conducted with "Roger" and "mask" as within-subject independent variables. Six separate ANOVAs were conducted to evaluate questionnaire scores as dependent variables (total score, and sub-scores for: cognitive, emotional, physical and social aspects of listening, and listening condition preference). The highly significant effect of Roger on the total scores ($F(1,15)=33.08$, $p<.001$) revealed better performance with the use of the Roger technology. There was a tendency, although no significance, for the use of masks to reduce the total scores for all conversations (with or without Roger). An examination of specific questionnaire items showed that Roger had the strongest effect on responses related to cognition (e.g., "How easy was it to shift attention to listen to somebody when they started to talk?"), followed by emotional reactions (e.g., "How successful do you feel you were in the conversation overall?"), physical reactions (e.g., "How tired were you after the conversation?"), and with the least effect on the social reactions (e.g., "Based on this conversation

Conclusions: how motivated would you be to participate in future group conversations?"). The final discussion's questionnaire confirmed that 93% of the participants expect a positive effect of Roger in a wide variety of listening situations."

Category: Hearing Loss / Rehabilitation

Poster #: 041

Impact of Hearing Loss on Communication During Telemedicine Encounters

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Objectives: Satisfaction with telemedicine is generally high, however it can lead to communication problems for people with hearing loss (HL), especially when encounters are conducted by telephone, because of the inability to see the face and lips on which many people with HL rely. Despite acknowledgement that HL might affect telemedicine outcomes, no studies have directly examined this. The primary aims of this study were to determine whether and how HL impacts patient satisfaction and willingness to use telemedicine.

Design: Opinions about telemedicine were assessed in an online survey of the general public completed between October 2020 and March 2021. Data regarding reported hearing ability, use of hearing assistive technology, and preferred form of communication (oral/aural versus sign language) were also collected and people with HL were intentionally oversampled. Survey items included closed set and open ended responses.

Complete surveys were received from 383 individuals of whom 44% said their hearing was average or better, 44% said their hearing was poorer than average and 12% said they were deaf. Of the 199 that used hearing assistive technology, 88% used hearing aids .

Results: At the time of the survey 75% of respondents had been offered a telemedicine appointment. Of these, 80.3% had been offered an appointment by phone, 3.5% had been offered a video appointment, and 16.2% had been offered both. Ninety percent of those offered a telemedicine appointment had accepted it. Of the 20 who refused a telemedicine appointment, 11 had poorer-than-average hearing and seven were deaf; 17 refused the appointment because of concerns about hearing. People with HL declined the offer of telemedicine appointments, rated telemedicine outcomes significantly less positively, and had stronger preferences for in person care than did people without HL. The reasons for this were directly associated with hearing-related difficulties or the indirect consequences of those difficulties. HL resulted in concerns about communication during telemedicine appointments, a lack of privacy when an intermediary helped with communication during the appointment, worries that critical information had been misheard/missed, and anxiety/stress associated with communicating by phone or video call.

Conclusions: The needs of people with HL during telemedicine encounters must be addressed to ensure equitable access. Healthcare providers should take responsibility to communicate clearly with people with HL and individuals with HL should be willing to advocate for their needs and use special access tools during telemedicine appointments.

Category: Hearing Loss / Rehabilitation

Poster #: 042

How do Audiologists Address their Client's Psychosocial Needs?

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Objectives: Rates of social isolation and loneliness are reaching epidemic proportions, with one in two adults reporting feeling lonely on a weekly basis, and one in four reporting chronic loneliness. The significant contribution of hearing loss to isolation and loneliness has been documented in clinical and population studies with one study reporting risk of isolation to be almost doubled in persons with hearing loss compared with persons who had no hearing loss. What approaches do audiologists currently use to address their clients psychosocial wellbeing needs? Are clients receptive to these approaches?

Design: Concept mapping techniques were used to gather the perspectives of 65 international audiologists (37 in Australia, 8 USA, 7 UK, 6 Ireland, 3 Canada, 2 China, 1 Switzerland, and 1 Netherlands). Audiologists generated statements describing the ways in which the psychosocial needs of adults with hearing loss are addressed in the audiology setting, and then grouped the statements, via an online portal. Multidimensional scaling and hierarchical cluster analysis was used to identify key themes. Fifty-two adult hearing aid users rated each statement as to its benefit and acceptability in the audiology setting. A scatter plot was used to identify the individual approaches that were deemed most beneficial and acceptable by participants.

Results: Ninety-three approaches were identified across eight concepts: 1) Involving the family/significant others; 2) Client accountability; 3) Personalising the rehabilitation program; 4) Encouraging use of support and

community groups; 5) Referral for specialist support; 6) Focusing on social engagement; 7) Emotional support; 8) Identifying the clients' goals. The individual approaches that were deemed most beneficial and acceptable by audiologists and clients will be presented.

Conclusions: Audiologists can help their client's improve their psychosocial wellbeing through programs that personalise goal identification and rehabilitation, explore and address psychosocial impacts of hearing loss, involve significant others, recommend external support, and promote self-management.

HEARING SCIENCE / PSYCHOACOUSTICS

Category: Hearing Science / Psychoacoustics

Poster #: 043

Auditory Enhancement Under Simultaneous Masking in Normal-Hearing and Hearing-Impaired Listeners

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Objectives: Auditory enhancement refers to the situation where one sound, embedded in a masker, becomes more audible when it is preceded by a copy of the masker. This effect of context likely reflects mechanisms that help us hear out novel sounds in ongoing backgrounds and provide us with perceptual constancy of important sounds, such as speech, in the face of different talkers and varying room acoustics. Depending on the paradigm, auditory enhancement can exceed 20 dB in young listeners with normal hearing. Our objective was to determine whether such enhancement is affected by age and/or hearing loss.

Design: Groups of young normal-hearing (YNH) listeners, hearing-impaired (HI) listeners (mean 4F-PTA = 39 dB HL), and normal-hearing listeners age-matched to the HI group (ANH) were recruited. Participants were presented with a five-tone complex and had to judge whether or not a probe tone presented after the complex was at the same frequency as one of the components in the complex tone, termed the target. The frequency range of the complex tone was roved between trials, but the target was always the center tone, with a mean frequency of 1414 Hz. The spacing between adjacent tones within the complex was always 0.6 octaves for the ANH and YNH groups and was either 0.6, 1.2, or 1.8 octaves for the HI group. The complex was either presented in isolation or was preceded by a copy of the complex without the target (enhancer) or by a copy of the complex with the target (control). The level of the target tone, relative to the other tones in the complex, was adaptively varied to estimate threshold. The level of the complex tones was set to 70 dB SPL per component for the HI and ANH groups. The ANH and YNH groups were additionally tested in the presence of a background noise, designed to simulate the audibility experienced by members of the HI group. Finally, the YNH group was also tested at the more typical level of 45 dB SPL per component.

Results: Average enhancement for the HI group was between 5 and 10 dB, or a factor of 2 to 4 less than typically found in YNH listeners. Surprisingly, similarly small amounts of enhancement were observed for both the ANH and the YNH when the stimulus level was 70 dB SPL per component, with or without additional background noise. However, when the YNH were tested at the lower level of 45 dB SPL per component, more typical enhancement of 15-20 dB was observed.

Conclusions: Large differences in enhancement were observed between HI listeners tested at high levels (to ensure audibility) and YNH listeners at low levels. However, the difference appears to be due to overall presentation level, rather than any specific effects of hearing loss or age. The results suggest that HI listeners lose the perceptual benefits of enhancement due to the high sound levels that are necessary to ensure audibility. It may be possible to restore some enhancement effects via frequency-specific automatic gain control.

Category: Hearing Science / Psychoacoustics

Poster #: 044

Remote-Frequency Masking and Speech Perception in Adults

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Objectives: This study aims to evaluate effects of various narrowband maskers on adults' perception of narrowband speech that is remote in frequency from the masker band and examine the association of these effects with the effect of multitone maskers on pure tone detection.

Design: Twelve subjects aged 22-34, with hearing thresholds no worse than 15 dB HL for frequencies 250-8000 Hz, participated in two listening tasks. In the speech perception task, coordinate response measure (CRM) sentences and their maskers were separately filtered into two ± 0.5 -octave wide frequency bands with respective center frequencies of 500 Hz (low-band) and 2500 Hz (high-band). Several types of maskers were utilized, including Gaussian noise, CRM sentences spoken by a talker different from the talker of the target sentences (speech-masked conditions), and time-reversed CRM sentences. Reception thresholds (SRTs) of either low- or high-band sentences were assessed in quiet and in the presence of a high- or low-band masker. Speech recognition scores (SRSs), or the percentages of keywords correctly identified, were measured in the same conditions with sentences presented at 7 dB above respective SRTs. In the informational masking task, detection thresholds of a 512-ms, 1 kHz tone were measured in quiet and in the presence of a masker consisting of 10 tones, each at 60 dB SPL, with frequencies randomly selected between 200- 5000 Hz excluding the range between 707-1414 Hz.

Results: Preliminary analyses indicated that SRTs were lower (better) for high-band sentences than for low-band sentences, and lower in the masked conditions (excluding the speech-masked conditions) than in quiet. SRSs were higher in quiet than in the speech-masked conditions, but comparable in quiet and other masked conditions. The masked-to-quiet detection threshold difference for the 1 kHz tone appeared to be positively correlated with the SRT for low-band sentences in Gaussian noise, but did not show correlations with SRS in any conditions or any masked-to-quiet SRS difference.

Conclusions: Our data indicate that when speech is presented in a single narrow-frequency band, listeners tend to receive more information from the frequency range around 2500 Hz as opposed to 500 Hz. When speech is borderline audible, non-speech maskers that are remote from speech in frequency may increase speech recognition, although these maskers do not appear to affect speech recognition when speech is adequately audible. In contrast, the recognition of adequately-audible target speech is negatively affected by speech maskers remote in frequency from the target, consistent with informational masking. While the informational masking effect on pure tone detection does not show direct link with the informational masking generated by speech maskers, the preliminary positive correlation between SRTs in some masked conditions and the pure

tone threshold increase due to informational masking suggests potential links between effects of remote-frequency non-speech maskers on the reception of non-speech and speech targets.

Category: Hearing Science / Psychoacoustics

Poster #: 045

Visual Speech Cues Facilitate Incremental Processing of Acoustically Degraded Speech

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Objectives: Listeners use phonotactic knowledge to anticipate word identity as they process speech input in real time. Acoustically degrading speech disrupts this processes, resulting in slower and oftentimes inaccurate speech recognition. In these situations, listeners can leverage coincident visual speech cues to improve recognition accuracy. Because visual speech cues can disambiguate acoustically degraded speech, even at the phonemic level, we hypothesize that visual speech cues speed recognition of acoustically degraded words. To test this hypothesis, we are implementing a word gating task, whereby listeners are asked to recognize target words when provided with partial phonetic content. We predict that listeners will require fewer gates of phonetic content to recognize acoustically degraded words when they have access to coincident visual speech cues. The present study was designed to pilot a subset of newly-created stimuli in young adults, with the ultimate goal of expanding the participant sample to school-age children.

Design: Sixteen young adults (ages 14 - 26 years) were recruited to complete an audiovisual and auditory-only gating task. The target speech stimuli were low-predictability sentences ending in a disyllabic target word (e.g., "She sees the banjo."). A native-English speaking female with a midwestern dialect produced all stimuli while she was audio- and video-recorded. The final words of each sentence were temporally divided into 5 gates that contained subsequently more phonetic content: phonological onset, +100 ms, +200 ms, +300 ms, and the whole word. Each participant was assigned to either a control condition, whereby speech was presented with full spectral resolution, or a degraded speech condition, whereby speech was noise-band vocoded into eight spectral channels. Within a condition, participants were presented with an equal number of auditory-only and audiovisual trials. Target words were counterbalanced across the auditory-only and audiovisual modalities so that each participant heard each target word in only one modality. Trials were blocked by gate, with earlier gates preceding later gates. Data are summarized by recognition accuracy of the target words at each temporal gate.

Results: Adults recognized words with less phonetic information (i.e., fewer gates) in the control versus the degraded speech conditions, consistent with the idea that spectral degradation slows word recognition. In the degraded speech condition, adults were more successful at recognizing words when they had access to visual speech cues, suggesting that coincident audiovisual speech facilitated word recognition. There was no benefit of visual speech cues in the control condition.

Conclusions: When speech is spectrally degraded, visual speech cues may support lexical activation in young adults. Audiovisual gating tasks may provide an additional way to quantify the effects of visual speech cues on lexical access.

Category: Hearing Science / Psychoacoustics

Poster #: 046

Perception of Interrupted Speech and Text: Listener and Modality Factors

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Objectives: In many real-world environments, speech signals reaching the listener are degraded and contain only partial information. Linguistic closure based on context to fill the gaps in the signal may involve overlapping perceptual processes for degraded speech and text. Past work indicates similarities in the perception of systematically interrupted linguistic signals in auditory and visual modalities. However, the effects of age and hearing loss on recognition of similarly interrupted speech and text in relation to recognition of speech in noise remain unclear.

Design: In the current study, a previously developed method to equate the signal interruptions across the two modalities was applied to spoken and printed sentences to obtain stimuli interrupted at the rate of 2-Hz with four duty cycles, which preserved 50% to 100% of speech and text. These stimuli, along with the uninterrupted Revised Speech Perception in Noise (R-SPIN) sentences in multi-talker babble at 0 dB signal-to-noise ratio, were administered to 100 adults in four listener groups: (i) younger normal hearing, (ii) older normal hearing, (iii) older hearing impaired with spectral shaping, (iv) younger listening to spectrally shaped speech in threshold matching noise.

Results: Based on the 50% point on the psychometric function relating percent correct scores to the four duty cycles, participants in all groups needed more information to obtain 50% correct with text than with speech. Furthermore, no differences in duty cycle needed for 50% recognition were observed across the four groups for text, whereas a shorter duty cycle was needed by young normal hearing participants than by the other groups to achieve 50% recognition for speech. Controlling for age and hearing abilities, correlational analyses averaged across groups revealed no significant correlations between the duty cycles needed for 50% recognition of interrupted speech and text. Moderate-to-large negative correlations were observed between duty cycles for 50% recognition of interrupted speech and scores for uninterrupted R-SPIN high and low predictability sentences ($r = -0.58$, $p < 0.001$ and $r = -0.49$, $p < 0.001$, respectively). In contrast, only low negative correlations were observed with interrupted text ($r = -0.28$, $p = 0.02$ and $r = -0.19$, $p = 0.11$, respectively). That is, better keyword recognition of low- and high-context sentences was moderately associated with shorter duty cycles needed for 50% recognition of interrupted speech, but much less so for interrupted text.

Conclusions: Consistent with previous research, preliminary findings indicate that both age and hearing loss have a negative influence on the perception of interrupted speech, but not interrupted text. Stronger correlations with sentences in babble were observed between interrupted speech than text while controlling for age and hearing loss. Although perception of both interrupted speech and text involves linguistic closure to compensate for missing elements of the sensory signal, other factors such as age, hearing ability and signal quality may affect perceptual processing, leading to modality-specific differences in perceptual outcomes. Overall,

perception of interrupted speech appears to be a stronger predictor of recognition of speech in babble than interrupted text.

Category: Hearing Science / Psychoacoustics

Poster #: 047

Presentation Level Effect on Listening Effort: Pupillometry and Listening Span

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Objectives: The main objective of the study was to examine the effect of presentation level (PL) on two listening effort measures- pupillometry and listening span while listening to speech in noise. Interaction between different SNRs and PL was also examined. Listening effort was expected to increase with decrease in SNR resulting in increased pupil dilation and reduced listening span. The pupil dilation was also expected to reduce for the most difficult SNR conditions. We hypothesized that a higher presentation level would result in greater listening effort.

Design: Using a repeated measure design, we examined how presentation level (50- and 65-dB SPL) and SNR (+6 dB to -10 dB) affect listening effort and studied the interaction between SNR and PL. Tobii eye-tracker and custom MATLAB programming were used for stimulus presentation and data analysis. There was total 12 test conditions, each consisting of 20 sentences. An a priori power analysis indicated a minimum of 14 subjects to detect a medium effect at 0.05 alpha level with 0.8 power. Sixteen young, normal-hearing, native English speakers were tested for the study. The participants repeated the sentences in noise and were asked to recall the last words in a set of 5 sentences. Pupillometry was recorded during the sentence recognition and listening span was calculated from the word recall.

Results: Separate two-way rmANOVAs were conducted for pupillometry and listening span considering presentation level and SNR as independent variables. Both pupillometry ($F(3,46)=3.82, p<0.05$) and listening span ($F(5,75)=806.9, p<0.05$) showed significant increase in listening effort with decrease in SNR and speech recognition. Listening span did not vary significantly with presentation level. Pupil dilation showed increased effort at 65 dB PL compared to 50 dB across all SNRs except -10 dB SNR, but the difference was not significant. The interesting finding was that the pupil dilation indicated decrease in effort at the lowest SNR however, this decrease in effort at the lowest SNR was not present for 50 dB presentation level. The speech recognition scores were significantly poor at 3, 0, -3 and -6dB SNRs for 65 dB presentation level compared to 50 dB SPL level ($F(1,15)=14.19, p<0.05$).

Conclusions: The listening effort trend across SNRs agreed with previous studies. The presentation level effect on listening effort was a new finding. The linear increase in listening effort at 50 dB PL shows shift in tipping point for effort or point of disengagement towards a higher SNR when loudness of the stimulus is low. Lower effort indicated by pupillometry data for 50 dB presentation level, especially at 6 dB SNR where speech understanding was same across conditions indicates a possible relationship between loudness and effort. In addition, the difference in effort between presentation levels can be confounded by difference in speech understanding, at 3, 0, -3, and -6 dB SNRs. Since the observed power was low for presentation level main effect

and interaction ($1-\beta=0.181$, $\eta p^2=0.08$), further research is needed in the direction to replicate the results with a bigger sample size.

Category: Hearing Science / Psychoacoustics

Poster #: 048

Intensity Detection Threshold in the Chinchilla Carboplatin Animal Model

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Objectives: Intensity coding of acoustic stimuli plays a critical role in the perception of complex auditory stimuli such as speech. In previous studies, we showed that carboplatin-induced selective inner hair cell (IHC) loss, in chinchillas, had little effect on pure tone thresholds but significantly affected pure tone thresholds in noise and detection of gaps in continuous noise. In a more recent study, we showed that selective IHC loss had little effect on temporal summation as measured by detection of short duration tones. To assess whether the deficits observed in gap detection could be the result of poorer intensity coding, we devised a task to measure the Just Noticeable Difference (JND) for changes in sound intensity. This psychophysical task was used to evaluate chinchilla sensitivity to intensity changes before and after carboplatin, a treatment that reliably and selectively destroys 50 to 80% of IHC in this species. We hypothesized that JND thresholds would increase following carboplatin treatment, indicating that loss of IHC produces deficits in intensity coding. If this hypothesis is supported, JND intensity detection tasks could be used as a suprathreshold assay of selective IHC loss.

Design: Free feeding, young adult chinchillas were used for this study. Distortion product otoacoustic emissions (DPOAEs) and pure tone thresholds in quiet were evaluated to assess the status of cochlear nonlinearity and as a measure of overall hearing sensitivity. Chinchillas were conditioned to respond to changes in intensity of a continuous reference narrowband noise (bandwidth = 10). JND performance was assessed at center frequencies 1, 2, 4, 8, and 12 kHz and at two continuous reference noise levels: moderate (50 dB SPL) and high (70 dB SPL). The moderate-level condition initially increased by 15 dB to 65 dB SPL and the high-level condition initially increased by 10 dB to 80 dB SPL. An automated stair step procedure was then used to determine JND threshold with intensity decreasing by 0.5 dB steps for correct responses and increased by 2 dB for incorrect responses until the lowest level at which the animal achieved 66% correct was obtained. Final JND thresholds were determined by averaging thresholds from three test sessions. Following baseline testing, chinchillas received a single dose of 75 mg/kg of carboplatin. This dose has been shown to eliminate 50-80% of IHCs. DPOAEs, pure tone thresholds and intensity detection JND thresholds were re-assessed following a 21-day recovery period.

Results: Following carboplatin treatment, there were no significant elevation of pure tone thresholds and no significant changes to DPOAE, suggesting that hearing sensitivity had not changed. In contrast, chinchilla JND increased following carboplatin treatment.

Conclusions: These results indicate that loss of IHC impacted sensitivity to intensity changes in chinchillas. Our preliminary data supports that this model could be used to study the effects of cochlear pathologies involving loss of IHC.

Category: Hearing Science / Psychoacoustics

Poster #: 049

An Adaptive, Isotonic-Regression Based Approach for Crossover Frequency Measurement

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Objectives: The crossover frequency for a speech corpus is the frequency that divides the corpus' spectrum into two equally-intelligible subbands. Crossover frequencies are useful in intelligibility prediction and identification of frequency regions containing important speech recognition cues. However, the standard method for determining crossover frequencies uses large numbers of filtered speech recognition trials with cutoff frequencies above and below the actual crossover. Both mathematical analysis and simulation suggest that an adaptive up-down staircase algorithm using isotonic regression can measure the crossover frequency accurately with greater efficiency than the standard method. The goal of the present study is to test this conjecture with human subjects.

Design: Twenty young adult listeners with normal-hearing participated in two types of listening experiments, each using recorded consonant-vowel-consonant nonsense syllables (11 consonants, 5 vowels) spoken by a female talker and delivered over headphones. The first type used the standard measurement, in which psychometric functions are estimated for low-pass and high-pass filtered speech and the crossover frequency is taken from the intersection of those curves. The second experiment used comparisons of block trials for low-pass and high-pass filtered speech to adjust the mutual cutoff frequencies of the filters in 1/4-octave steps. Here, an updated crossover frequency estimate was computed after each block using isotonic regression. Ordering of the two types was counterbalanced across subjects. The listeners recorded their responses on a laptop, using drop-down menus for each phoneme.

Results: No significant differences were observed between participants' pairs of crossover frequencies. Yet, in both simulation and practice, the isotonic regression reached a stable estimate in less than 100 trials and exhibited better efficiency (i.e., equal variance in fewer trials) than the standard algorithm.

Conclusions: For listeners with normal hearing, an adaptive isotonic-regression based algorithm can be used to reduce the amount of computation required to measure speech crossover frequencies. This result has positive implications for measurement of Speech Intelligibility Index frequency importance functions and analysis of recognition cues in processed speech.

Category: Hearing Science / Psychoacoustics

Poster #: 050

Reverberation and Large Listener-talker Distances Increase Listening Effort in Adults

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Objectives: Existing models of listening effort have been challenged by mixed historical data on how listening effort is affected by reverberation and listener-to-speaker distance relative to critical distance. Our study investigated the effects of reverberation at different listener-to-speaker distances on behavioral and subjective effort: a) for a fixed signal-to-noise ratio (SNR) and b) for SNRs that were manipulated so that word recognition would be comparable across different reverberation times and listening distances. We hypothesized that increased reverberation would increase listening effort (i.e. longer response time and higher subjective reports of effort), but only when listening outside of the critical distance for the test room.

Design: Nineteen adults (11 females and 8 males, $\bar{X} = 31$, $s = 5.5$), ranging from 21 to 40 years of age participated in this repeated-measures study. All participants met the following criteria: (a) hearing thresholds better than 25 dB HL at audiometric octaves from 250 to 8000Hz, evaluated using a standard audiometry; (b) no history of chronic middle ear disease or neurologic disorder indicated by self-report; (c) native English speakers indicated by self-report; (d) no previous knowledge of reverberation and acoustics indicated by self-report. We conducted a semantic dual-task paradigm. The primary task was word recognition, and the secondary task was timed word categorization; response times during the secondary task indexed behavioral listening effort. Additionally, participants provided subjective ratings in each condition. We conducted testing in two reverberation levels (moderate and high, RT30 = 469 ms and 1223 ms, respectively), and two listener-to-speaker distances (inside and outside critical distance for the test room, 1.25 and 4m, respectively).

Results: Two-way repeated measures ANOVAs and two-way Friedman's tests were conducted. For fixed SNRs, increasing reverberation times and listening distances negatively affected word recognition (14 to 25 percentage point decrease on average) and behavioral listening effort (117ms to 145ms longer on average), but there was no interaction between reverberation and distance. When SNRs were manipulated to derive comparable word recognition, only listening distance affected behavioral effort (45ms longer on average. Under both "fixed SNR" and "comparable SNR" conditions, subjective ratings of "work" were in better agreement with behavioral effort compared to "effort". "Reverberation" ratings only increased with higher reverberation, not with increased listening distances.

Conclusions: The current study demonstrates that behavioral listening effort in the rooms can be increased under conditions of high reverberation and listening outside critical distance, but the effects are independent of each other under these conditions. Additionally, effect of reverberation on behavioral listening effort seems to be driven by the change in word recognition. Subjective reports of listening effort were also higher with increased reverberation and listening outside critical distance. Combined, these data indicate conditional effects of reverberation on listening effort and provide support for the expectations about effort set forth by the existing models of listening effort.

HEARING TECHNOLOGY / AMPLIFICATION

Category: Hearing Technology / Amplification

Poster #: 051

Evaluating Step Tracking Accuracy of Hearing Aids Using ANSI/CTA Standards

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Objectives: Physical activity is an essential part of healthy aging and well-being. Previous research has shown that moderate or greater degrees of hearing impairment in older adults is associated with decreased levels of physical activity. Tracking steps is a simple way to monitor and motivate physical activities. Literature shows that using step counters can help inactive individuals increase their step count by 2500 steps per day. Technological advances in hearing aids allow for tracking steps using embedded motion sensors. American National Standards Institute and Consumer Technology Association developed standardized procedures for evaluating step tracking accuracy (ANSI/CTA-2056). The purpose of this study was to evaluate step tracking accuracy for hearing aids with motion sensors following the procedures specified in ANSI/CTA-2056. It was of interest how accurate the embedded hearing aid sensors were able to track steps, using these recognized standards, given the location on the ears as opposed to the wrist.

Design: The participants in this study were 20 adults, age 22 to 58 (Mean = 38.2, SD = 9.3) without any self-reported physical disabilities. Data collection procedures specified in ANSI/CTA-2056 were strictly followed. Each participant wore a Starkey Evolv rechargeable RIC device, which is equipped with an Inertial Measurement Unit (IMU) motion sensor. The participant was instructed to walk and run naturally on a treadmill at 0% incline for 5 minutes, respectively. Walking speed was between 2.5 and 4 mph. Running speed was between 5 and 12 mph. Step count data was read from the Starkey Thrive app. Video recordings were taken to allow for the manual counting of steps following the study visit (ground truth).

Results: ANSI/CTA-2056 uses mean absolute percentage error (MAPE) to quantify measurement accuracy, which is calculated based on the difference between ground truth and device reading. The acceptance criterion is that the MAPE shall be within 10% separately for both walking and running. Step count data for the Evolv hearing aids were analyzed. The MAPE values for walking and running were 3.5% and 2.6%, respectively.

Conclusions: Step tracking accuracy can be influenced by factors such as the speed of movement, the position of the sensor, and the motion of the body. The procedures described in ANSI/CTA-2056 provide a standardized way to evaluate step tracking accuracy which ensure that the tracking device can provide valid information. By using these procedures, it was demonstrated that hearing aids with embedded IMU sensor can provide accurate step counts. Accuracy in step counting is an important element to encourage use of fitness tracking capabilities in hearing aids and motivate physical activity.

Category: Hearing Technology / Amplification

Poster #: 052

Accuracy of In-Situ Hearing Threshold Measurements from A Direct-To-Consumer Device

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Objectives: Current development in advanced consumer electronics allows manufacturers to develop direct to consumer (D2C) hearing devices. Such devices are thought to be market disruptors that may change the way patients, clinicians, and the industry operate and interact in the future. For example, they may offer a patient/user the flexibility of conducting in-situ hearing assessment through their device. The user can then customize the device based on the results of the hearing assessment. One of the major challenges facing the development of such technologies is how accurate their measurements are when compared to the clinical audiometric data. The overall goal of this study was to assess the accuracy and reliability of in-situ hearing

thresholds measured with a D2C device (Eargo Inc) relative to measurements made with a clinical audiometer following Audiology best practice methods.

Design: One hundred subjects were recruited from the University of the Pacific Hearing and Balance Center. Severity of hearing loss and usage of hearing aids varied amongst participants. Listeners' hearing thresholds were measured via an app (Eargo's Soundmatch™ feature) in an anechoic sound booth and a quiet room (with minimal background noise). The subjects self-administered hearing evaluation using Eargo devices and the app. Audiometer thresholds were obtained with an ANSI Type I clinical audiometer following clinical best practice methods. Audiometric thresholds were measured at octave frequencies between 0.5 and 4 kHz. Pearson's correlation coefficient (r) was calculated to compare the thresholds measured using both methods.

Results: Overall, audiometric thresholds measured using Eargo's Soundmatch™ in a booth and in a quiet room were comparable to the thresholds measured using Clinical best practice methods (no statistically significant differences between measures). The mean thresholds measured using Eargo devices/app in a booth were within 10 dB HL to the thresholds measured with a clinical audiometer at 91% accuracy. The mean thresholds measuring using Eargo devices/app in a quiet room had an accuracy of 90% relative to the clinical audiometer measurements. Statistically significant correlations were found between hearing thresholds obtained from Eargo in booth and the clinical audiometer, as well as between Eargo in a quiet room and the clinical audiometer ($p < 0.0001$).

Conclusions: The accuracy of Eargo measured thresholds were within the 10 dB HL test-retest reliability range typically used in clinical practice. Overall, the results from this study suggest that hearing assessment conducted with D2C devices such as Eargo can provide accurate and reliable inference about the hearing status of individuals compared to clinical best practice methods. In summary, manufacturers of D2C and/or OTC hearing devices could design their fitting strategies and formulas with reliable and accurate in-situ hearing measurements such those in this study.

Category: Hearing Technology / Amplification

Poster #: 053

Psychophysical Shortcomings in the Personalisation of Hearing Aids

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Objectives: In the personalisation of hearing aids, it is common practice to adjust gain away from prescription based on feedback from the patient. Underlying this personalisation process, though, are several assumptions about the perception of those adjustments, from the adjustments being adequately large enough and the stimuli adequately long enough to elicit a reliable preference to the feedback being reliable within and across patients. Through a series of psychophysical studies, we have explored the viability of those assumptions.

Design: To examine the scale of gain adjustments necessary to elicit reliable preferences from patients, 29 hearing-aid users judged whether varied adjustments in broad frequency bands away from their individual

settings were better, worse or no different when listening to speech of varying duration. To examine how much agreement there is within and across patients in their feedback, 28 online participants with similar minimal-to-mild hearing loss described the difference of gain adjustments away from median settings.

Results: The necessary gain adjustment to elicit a preference decreased and became more reliable with increasing stimulus duration, but the effect was limited, and the scale of the adjustment at longer durations was still larger than suggested by current guidelines. That is, speaking longer can lead to better fits, but only by so much. As to the assumption of reliable patient feedback in fine-tuning, while participants generally used some terms associated with hearing-aid gain, their usage lacked reliability within or across participants. That is, particular descriptors were not associated with any particular adjustment.

Conclusions: These findings highlight our misassumptions in the personalisation of hearing aids, and indicate that alternative approaches to personalising hearing-aid settings may be a more viable use of valuable clinical time.

Category: Hearing Technology / Amplification

Poster #: 054

Identifying Potential Otologic Disorders in a Direct-to-Consumer Model of Care

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Objectives: Self-fitting, direct-to-consumer (DTC), and over-the-counter hearing aids have expanded the opportunities for individuals to self-test their hearing. While improving the accessibility and affordability of hearing healthcare, a potential limitation of remote hearing testing is the inability to perform in-clinic diagnostic tests that could identify a medically modifiable otologic or otoneurologic condition. The Consumer Ear Disease Risk Assessment (CEDRA) can serve as a critical tool for identifying potential risk factors in the emerging DTC landscape. The objective of this poster is to describe a use case for CEDRA in a commercial, DTC model of care.

Design: We will review the anonymized CEDRA results of all clients who opted to purchase hearing aids through the Listen Lively website or app following completing an online hearing test or uploading the results of a clinically-administered hearing evaluation. We will describe a CEDRA categorization system developed by Lively, the distribution of CEDRA scores into these categories, the follow-up process, and the disposition of clients as a function of score/category and audiologist review.

Results: The results through the 3rd quarter of 2021 indicated that approximately 18% of CEDRA results were flagged for follow-up. Following review and/or consultation with a Lively audiologist, approximately 35% of those flagged had their orders cancelled or returned their hearing aids for credit, representing .07% of all hearing aid orders.

Conclusions: The CEDRA, coupled with follow-up by an audiologist, could be an effective tool for identifying individuals at potential risk for otologic or otoneurologic disease indicating the need for further investigation

prior to hearing aid use. Such a vigilance system has an important role to play in an emerging DTC hearing healthcare landscape.

Category: Hearing Technology / Amplification

Poster #: 055

Implementing Ecological Momentary Assessment in Clinical Research: Recommendations and Cautions

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Objectives: Two studies using Ecological Momentary Assessment (EMA) were conducted to collect quantifiable data about the listening environments of study participants during home-trials. The implementation of EMA in these studies differed. In one study, the EMA application prompted the study participants to answer short surveys according to environmental triggers defined by the researcher. In the other, the participants were instructed to choose when to use the application according to guidance provided by the researcher. Through these investigations, the researchers collected learnings about the advantages and disadvantages of using EMA in clinical research using these two implementations. Such learnings can be used to steer decisions regarding study design in future clinical research projects.

Design: Study #1: Twenty participants were given an ecological momentary assessment mobile application for a one-week home trial. Ten participants were experienced hearing aid users with moderate hearing loss and ten participants had normal or near-normal hearing with no previous hearing aid experience. All participants were fit with a pair of receiver-in-the-canal hearing aids that were paired to an investigational EMA mobile application. The application was designed to prompt the participants to complete short surveys. The application prompts occurred according to environmental triggers defined by the researcher to best address the research questions of the study. Study #2: Eighteen experienced hearing aid users with moderate to moderately severe hearing loss were enrolled in this study. The participants were given an ecological momentary assessment mobile application for a four-week home trial. They were also fit with a pair of receiver-in-the-canal hearing aids that were paired to an investigational EMA mobile application. The participants were instructed to access the application when they were in speech-in-noise listening environments per a verbal definition provided by the researcher. Accessing the application was entirely self-directed. There were no automated environmental triggers to prompt the participants to use the application.

Results: Differences arose between using prompted ecological momentary assessment and self-directed ecological momentary assessment. These differences included the quantity of the data collected, the relevancy of the data as it pertained to the research questions, and the subjective feedback gathered from the study participants regarding their satisfaction with using the applications. Prompted ecological momentary assessment increased the relevancy of the data, but was lacking in quantity due to either the prompts occurring at inconvenient times or the participant missing the prompts. Conversely, self-directed ecological momentary assessment increased the quantity of data, but was lacking in relevancy due to variability in how participants interpreted the guidance provided by the researcher.

Conclusions: Research has shown that ecological momentary assessment increases the validity of data collected for clinical research; however, the implementation of it can have a significant effect on its usefulness. For example, studies investigating specific hearing aid technologies demand highly relevant data in which the testing environment is matched to the intended use case. Such studies would be better suited for a prompted

EMA methodology. Conversely, investigations into overall system performance would be better suited for self-directed EMA methodology. The researchers have gathered recommendations and cautions for implementing ecological momentary assessment in clinical research according to their own learnings and from what is available in the literature.

Category: Hearing Technology / Amplification

Poster #: 056

An Information Kiosk for Hearing Help Seekers with Low Incomes

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Objectives: The Food and Drug Administration (FDA) has released proposed regulations for public comment about the sale and purchase of over the counter (OTC) hearing aids for those with mild and moderate hearing losses. As of January 2022, nearly all direct-to-consumer hearing aids are sold online which is expected to change with the finalization of the OTC regulations. Hearing help seekers with low incomes require up to date information regarding implications for where they obtain hearing aids and what to be wary of if purchasing them online. Our aim was to develop an information kiosk for hearing help seekers with low incomes presenting to a community hearing aid bank.

Design: This is a case study of use of an information kiosk for counseling hearing help seekers with low incomes presenting to a community hearing aid bank. The information kiosk was placed in clinic waiting rooms with attendants to answer questions and assist. A handout and a 15-minute ZOOM presentation were made available to new patients in English or Spanish about the impact of untreated sensorineural hearing loss (SNHL); our community hearing aid bank; hearing aids and their features; up to date news, advantages, and disadvantages of OTC devices; and how to be a savvy consumer if pursuing amplification online. Consumer tips were developed from a cross-sectional survey of online hearing aid distributors' policies and use of advertising ploys (e.g., scarcity, urgency, BOGO, free accessories, "expert" opinion, pricing psychology [prices ending in -99, false reductions, decoys, event sales], enhanced visuals and technology claims). Patients and providers completed a survey to give feedback about the use of the information kiosk.

Results: Initial feedback about the information kiosk from patients and providers has been positive. Patients appreciated knowing about the impact of untreated SNHL, hearing aids, our program, and other options for obtaining hearing aids prior to their initial consult. Providers believed that their time was better spent with patients who were informed and came prepared with questions.

Conclusions: The information kiosk has been beneficial for use in our community hearing aid bank during this time of change in the hearing healthcare industry. It is important that patients know about all their options so that they may participate effectively in making hearing healthcare decisions.

Category: Hearing Technology / Amplification

Poster #: 057

Adaptive Low-Level Gain in Pediatric Hearing Aid Fittings

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Objectives: Among the hearing-aid prescriptions available to audiologists, children with hearing loss have expressed a preference for the Desired Sensation Level (DSL) prescription - which emphasizes audibility - when listening to soft or distant speech in quiet, and a preference for the National Acoustic Laboratory (NAL) prescription - which emphasizes listening comfort - in noisy environments. Thus, neither prescriptive strategy seems optimal for all listening situations children encounter. Indeed, children have expressed a desire to have access to both prescriptions, though this is not possible with current hearing instrument technology. A new hearing aid feature (Speech Enhancer) designed to adaptively increase gain for low-level speech at frequencies ≤ 3 kHz may provide a way to better manage both noise and soft speech, thereby optimizing comfort and audibility. The objective of this study was to evaluate the contribution of Speech Enhancer to both DSL and NAL amplification strategies on perception and memory of new and familiar words in children and adolescents with hearing loss.

Design: Sixteen participants between 9 and 17 years of age with moderate to severe hearing loss were fit with Phonak Audéo P90-R receiver-in-the-canal hearing aids during laboratory testing which consisted of two 90-minute sessions. The devices were fitted with one hearing aid prescription per session (DSL or NAL). The order of the prescriptive fittings was counterbalanced across sessions. The test battery included measures of: 1) ampclusion (i.e., level of the child's own voice in the ear canal with amplification), 2) traditional speech recognition threshold, 3) speech recognition threshold with real and nonsense words, 4) single word recognition, 5) multi-word recognition, 6) nonsense word identification within short sentences, 7) novel word learning and 8) next-day recall of newly learned words. The stimuli for all suprathreshold tasks were presented at 40- and 70-dBA in the sound field. Each task was conducted with the Speech Enhancer feature enabled and again with it disabled.

Results: Equivalent outcomes were observed across fitting prescriptions for all tasks with the exception of single word recognition in the low-level listening condition and real/non-word reception threshold. Performance for these tasks was significantly better with the DSL prescription compared to the NAL prescription ($p < .05$). These differences disappeared when the low-level adaptive gain feature was activated. Additionally, the level of the children's own voice decreased significantly ($p < .05$) while next-day recall of the learned words approached significance ($p = .07$) when the adaptive gain feature was activated.

Conclusions: The results of this study suggest that there are few differences in the behavioral outcomes of children and adolescents receiving DSL- and NAL-prescribed amplification. One exception is the recognition of individual, low-level words at and slightly above threshold, but many of these differences were resolved with the use of low-level adaptive gain. Thus, a feature like Speech Enhancer may provide more options to pediatric audiologists attempting to optimize audibility for low-level speech without compromising listening comfort for high-level speech.

Category: Hearing Technology / Amplification

Poster #: 058

Speech and Quality with Over-the-Counter and Traditional Amplification

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Objectives: Hearing aids have traditionally been a beneficial option for individuals with any degree of hearing loss, but they often come at a high out-of-pocket price. In 2017, the Food and Drug Administration (FDA) approved over-the-counter (OTC) hearing aids. In 2021, the FDA published proposed safety and efficacy regulations for OTC hearing aids and detailed descriptions of OTC hearing aids, traditional clinician-fit hearing aids, and other direct-to-consumer amplification devices (such as personal sound amplification devices to help with hearing in noise). Despite OTC hearing aids being designated for individuals with mild-to-moderate hearing loss, individuals with greater degrees of hearing loss might purchase these devices for hearing benefit. Can these devices provide adequate hearing benefit? The current research compares traditional hearing aids to some direct to consumer options for speech perception and sound quality with three degrees of hearing loss. We hypothesized that traditional hearing aids would provide better speech intelligibility than OTC devices, but that sound quality might vary depending on the degree of hearing loss and listening situation.

Design: Adults with normal hearing and with simulated hearing loss (flat moderate, mild to moderate, mild to severe) completed speech perception testing with and rated the sound quality of 9 devices (6 OTC devices and 3 traditional HAs). Each device was programmed to match prescriptive targets for hearing aid output for the three hearing losses using real-ear verification in the manikin. To allow efficient testing with multiple amplification devices, recordings of speech perception and sound quality materials were made with each device in an acoustic mannequin in a double-walled soundbooth. Participants completed all testing for the recordings presented via headphones. Sound quality ratings were completed for four sound scenarios (music, traffic, party, nature) using the MUlti Stimulus test with Hidden Reference and Anchor test. Participants rated the sound quality of each sound scenario with each of the nine devices as well as the original sound and the unamplified sound with a simulated hearing loss. All participants completed sound ratings for all three simulated hearing losses, with the order of hearing loss and sound scenario randomized. Participants completed speech recognition testing using the QuickSIN resulting in a signal-to-noise ratio (SNR) loss for each device. Due to a limited number of sentence lists, each participant only completed speech recognition for one randomly assigned simulated hearing loss.

Results: Preliminary data indicate that hearing loss generally decreased sound quality and speech perception, but all devices generally increased sound quality and speech perception for participants. Some individual hearing aids and OTCs had better sound quality than other devices depending on the listening situation and degree of hearing loss. Only a couple of the OTCs resulted in poorer speech perception than all the other devices. In general, sound quality and speech perception varied for devices across the different hearing losses.

Conclusions: Based on preliminary data, the researchers conclude at least some over-the-counter hearing aids and amplification devices do not provide adequate speech perception for mild sloping to severe hearing loss. Additionally, sound quality varies across both hearing aids and OTCs depending on the listening situation.

PEDIATRIC AUDIOLOGY / OTOTOLOGY

Category: Pediatric Audiology / Otology

Poster #: 059

Retrieval Practice and Word Learning in Children with Hearing Loss

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Objectives: Children with hearing loss (HL) show poorer vocabulary outcomes than children with normal hearing (NH), even when early amplification and intervention are received. The goal of the study was to test the effectiveness of three word-learning conditions: no retrieval, immediate retrieval, and spaced retrieval. It was hypothesized that if retrieving words when the answer is not present ("quizzing effect") helps encode words in long-term memory, then spaced-word retrieval will be a more effective strategy than no retrieval and immediate retrieval.

Design: Twenty-one children with NH and 21 children with HL (9 hard of hearing and 12 deaf) between 4 and 8 years of age completed an experimental task to assess word learning at three points in time: in the lab (training), a day after, and a week after. Groups by hearing status (NH, hard of hearing, and deaf) did not differ by age, maternal education, or non-verbal intelligence.

Results: Repeated measures ANCOVAs controlling for age revealed no main effects or interaction between learning condition and hearing status on word recognition in the lab. However, a significant interaction between learning condition and hearing status was observed a day after ($F [4, 76] = 4.032, p = .005, \eta^2 = .175$) and a week after training ($F [4, 76] = 3.991, p = .005, \eta^2 = .174$). Follow-up pairwise comparisons for day 1 revealed that children with NH remembered more words in the spaced retrieval than in the no retrieval condition. Children who were deaf remembered more words in the no retrieval and immediate retrieval than in the spaced retrieval condition. Pairwise comparisons for week 1 revealed that children with NH remembered more words in the immediate retrieval than in the no retrieval condition. Children who were hard of hearing remembered more words in the immediate retrieval and spaced retrieval than in the no retrieval condition.

Conclusions: In agreement with previous studies, spaced retrieval was an effective strategy for children with NH to remember words a day after training. However, its effect disappeared after a week. For children who were hard of hearing, retrieving words (either immediately after exposure or spaced) helped them remember more words a week after training. Children who were deaf did not benefit from spaced retrieval and remembered more words in the no retrieval and immediate retrieval conditions a day after training. It is possible that spaced retrieval was too hard for children who were deaf given their small vocabularies, needing more exposures and retrievals to benefit from this strategy. Future studies should investigate word learning in children with HL longitudinally to truly assess the effect of different learning conditions on word retention.

Category: Pediatric Audiology / Otology

Poster #: 060

Listening Fatigue and School Accommodations in Adolescents with Hearing Loss

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Objectives: Listeners with hearing loss require greater listening effort than those with normal hearing to understand speech in complex environments. This increased listening effort can lead to listening-related fatigue. It is known that elementary-age children with hearing loss experience higher subjective fatigue than peers with

normal hearing. Older adolescents with hearing loss, however, remain an under-studied population. In particular, the effects of school accommodations, such as remote microphones and closed captioning, on listening fatigue remain unknown. School accommodations can improve access to speech in the classroom, but it is unclear if these accommodations alleviate listening fatigue. Our primary objective was to examine the association between listening fatigue and use of school accommodations among adolescents with hearing loss. We hypothesized that adolescents who use more accommodations would experience lower listening fatigue. Additionally, we examined the effect of school setting (i.e., in-person vs. remote classes) on listening fatigue, hypothesizing that adolescents participating in in-person learning would experience greater listening fatigue. Finally, exploratory analyses examined the effects of age and device configuration (e.g., hearing aids vs. cochlear implants) on listening fatigue.

Design: We administered a Qualtrics survey to adolescents ages 11 to 18 years with any degree of hearing loss, unilaterally or bilaterally. Information was collected about participants' use of hearing devices, participants' experiences with listening fatigue, and the extent to which participants use various school accommodations (remote microphone, closed captioning, live transcriptions, preferential seating, ASL interpreter, note taker, and extended test times). Listening fatigue was quantified using the Vanderbilt Fatigue Scale-Child. A total of 286 participants completed the survey. After excluding responses that likely were not completely truthfully, 116 responses were included in statistical analyses. Participants included 46 girls, 69 boys, and 1 participant who was non-binary/other gender, in 5th through 12th grade. Mean age was 15.2 years (SD = 1.64). Device configurations included various combinations of hearing aids, cochlear implants, bone conduction devices, and CROS devices.

Results: Contrary to our hypothesis, higher use of school accommodations was associated with increased listening fatigue, $r = .53$, $p < .001$. No significant difference in listening fatigue was found between participants taking classes remotely or in-person, $t(81) = -0.06$, $p = .95$. Exploratory analysis revealed that age was negatively associated with listening fatigue, $r = -.28$, $p = .003$. Furthermore, listening fatigue differed significantly based on device configuration, $F(9,100) = 5.25$, $p < .001$. Participants with unilateral hearing loss experienced lower listening fatigue than participants with bilateral hearing loss. However, participants with bilateral hearing aids experienced similar listening fatigue as participants with bilateral cochlear implants.

Conclusions: Adolescents who experience greater listening fatigue may be more prone to utilizing school accommodations, but these accommodations may not alleviate listening fatigue. Even with substantial classroom support, adolescents with hearing loss are at risk for fatigue due to everyday listening. Despite presumably having milder hearing losses, adolescents with hearing aids experience similar listening fatigue as those with cochlear implants. Audiologists should be aware of the listening difficulties experienced by adolescents with all degrees of hearing loss.

Category: Pediatric Audiology / Otology

Poster #: 061

Listening-Related Fatigue in Children: Child Self-Report vs. Proxy-Report

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Objectives: Fatigue is a subjective experience, associated with feelings of low energy and tiredness. Fatigue is common when high levels of effort are applied towards a task. Research suggests that children with hearing loss (CHL) may be at increased risk for significant listening-related fatigue- fatigue resulting from sustained or high levels of effort applied towards a listening task. Given fatigue's subjective nature, the gold standard for measurement is self-report ratings; however, abstract constructs like fatigue may be difficult for some children to reliably describe. In such cases, useful information could potentially be obtained via parent-proxy responses. However, prior work from our lab, using a generic fatigue scale (Pediatric Quality of Life-Multidimensional Fatigue Scale), revealed only weak agreement between child self-report and parent-proxy report. In addition, parents often underestimated the fatigue reported by their children. This poster investigates associations between child self-report and parent-proxy reports of fatigue using a measure specially designed to assess listening-related fatigue- the child and parent versions of the Vanderbilt Fatigue Scale (VFS-C & VFS-P).

Design: Data for this study were collected as part of a larger study to develop and validate the pediatric versions of the Vanderbilt Fatigue Scales. Study participants included children with and without hearing loss (CNHL) and their parents. Participants were recruited during routine visits to an Audiology clinic and via multiple online recruitment methods. Participants completed the child or parent version of the Vanderbilt Fatigue Scale. The VFS-C is a unidimensional instrument, providing a single measure of listening-related fatigue. In contrast, the VFS-P is multidimensional, providing separate estimates of mental (VFS-PMental) and physical (VFS-PPhysical) fatigue. A total of 222 children (aged 6-17 years) and their parents participated. We used T-tests and correlation analyses to examine concordance between ratings of listening-related fatigue obtained via child self-report and parent-proxy reports.

Results: Initial analyses revealed relatively strong concordance between child self-report and parent-proxy reports using the VFS (ICC=0.65 & 0.62, $p < .001$, comparing VFS-C and VFS-PMental and VFS-PPhysical ratings, respectively). A comparison of parent and child summed scores (in percent) revealed no significant difference ($t(432) = 1.2$, $p = .23$) between mean VFS-C ($M = 47.2$; $SD = 22.8$) and VFS-PMental scores ($M = 44.4$; $SD = 25.9$). However, mean VFS-PPhysical ratings ($M = 56.8$; $SD = 24.1$) were significantly higher than VFS-C ratings ($t(438) = -4.3$, $p < .001$), suggesting parents tended to overestimate the physical effects of listening-related fatigue on their child. A visual analysis of the data (scatter plot of child/parent scores) suggests this is primarily an issue for children reporting low-levels of listening-related fatigue. Exploratory analyses examining concordance separately for CHL and CNHL will also be completed and reported.

Conclusions: In contrast to our prior work using a generic fatigue scale, initial analyses revealed strong correlations between VFS ratings of listening-related fatigue provided by the child and their parent-proxies. In addition, there was moderate absolute agreement between child ratings and VFS-PMental scores. There was, however, a tendency for parents to overestimate the physical impact of listening-related fatigue on their children.

Category: Pediatric Audiology / Otology

Poster #: 062

A Predictive Tool: Behavioral Infant Speech Perception and Report of Early Language

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Objectives: The objective of our research is to examine the relationship between behavioral infant speech perception measured using a clinically recommended tool at 7 months of age and expressive language outcomes at 16, 24 and 30 months of age using a parent report measure. Recent studies among children with normal hearing (CNH) suggest that infant speech perception is predictive of later language abilities. Our research expands beyond the current body of literature and explores the relationship between CNH and children who were hard of hearing (CHH). Monitoring speech perception abilities could refine early interventions during a period of rapid language development. We hypothesize that speech perception abilities greater than $d' \geq 1.21$ will be related larger vocabulary size within their expected age range.

Design: Infant speech perception was assessed using a conditioned head turn procedure to contrasts /a-i/ and /ba-da/ at three presentation levels (50, 60 and 70 dBA SPL). Early spoken language was quantified using MacArthur Bates Communicative Development Inventories (MBCDI) Words and Sentences, completed by the child's caregiver. The MBCDI provides information about vocabulary, word produced, gestures, and grammar. CHH met the EHDI 1-3-6 benchmarks for detection and intervention. Average age at hearing aid fit was 3 months of age. Relationships were examined between speech perception testing and MBCDI scores at 16-months (48 CHH, 54 CNH), 24-months (38 CHH, 49 CNH), and 30-months (38 CHH, 47 CNH).

Results: Data analysis included linear regressions between behavioral speech perception and survey scores at each time for the overall group and across hearing status. Preliminary analysis indicates relationships between early speech perception abilities and later language abilities by parent report. Preliminary results suggest vowel discrimination may be a better predictor of early language abilities across groups.

Conclusions: Results suggest that infant speech perception is correlated with report of early language. Better understanding this relationship is the next step towards establishing a clinically valid measure of infant speech perception. Data collection is ongoing but will be completed at time of presentation.

Category: Pediatric Audiology / Otology

Poster #: 063

Prevalence and Clinical Presentation of CND in Children with ANSD

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Objectives: Disorders of the auditory nerve such as Auditory Neuropathy Spectrum Disorder (ANSD) and Cochlear Nerve Deficiency (CND) can significantly impact the ability of children to hear and develop language. While ANSD is diagnosed via auditory brainstem response (ABR) testing, these results cannot indicate the

status of the auditory nerve. This results in delayed differential diagnosis between ANSD with a present auditory nerve and ANSD with concomitant CND. Furthermore, appropriate intervention options, including candidacy for cochlear implantation, cannot be established until the status of the auditory nerve is determined via imaging. Intervention for children with ANSD can, therefore, be delayed if imaging cannot be obtained in a timely manner, which may negatively impact outcomes. The purpose of this study was to assess the prevalence of CND in a cohort of children with ANSD, and to explore trends in clinical presentation that may predict auditory nerve status in children with ANSD prior to imaging.

Design: Retrospective chart review was conducted for 63 children 0 to 21 years of age who were diagnosed with ANSD in at least one ear. Diagnostic criteria for ANSD included the presence of a cochlear microphonic with absent or grossly abnormal neural ABR waveforms or present distortion product otoacoustic emissions (DPOAEs) with behaviorally obtained sensorineural hearing loss, both suggesting normal outer hair cell function with abnormal auditory nerve function. The rate of CND in the cohort of children with ANSD was assessed. Diagnostic criteria for CND included radiology reports noting an "absent or hypoplastic nerve" and/or a "narrow internal auditory canal and/or stenotic cochlear aperture" on imaging. Clinical presentation was quantified by audiologic results obtained via ABR, auditory steady-state response (ASSR), DPOAE, and behavioral audiometric testing.

Results: Of the 63 children in this cohort, imaging results were unavailable for 23 children with ANSD (16 unilateral; 7 bilateral). Of the 40 children with ANSD for whom imaging results were available (16 unilateral; 24 bilateral), concomitant CND was present in 63% of unilateral presentations and 17% of bilateral presentations. Preliminary analysis of audiologic test results suggests present or partially-present DPOAEs were observed equally as often in ears with ANSD and ears with ANSD and CND. While there were no measurable neural responses on ABR for any ears with ANSD, thresholds obtained via ASSR and behavioral audiometry tended to be better (i.e., lower) for ears with ANSD than ears with ANSD and CND.

Conclusions: Concomitant diagnosis of CND in ears with ANSD is relatively common in children, especially when the presentation is unilateral. DPOAE and ABR results did not reveal trends pertaining to auditory nerve status; however, slightly better thresholds were observed on ASSR and behavioral testing for ears with ANSD and a present auditory nerve. This observation does not recommend the use of ASSR to determine hearing sensitivity in children with ANSD, but rather suggests ASSR may provide additional information to predict auditory nerve status prior to imaging. Most importantly, these results highlight the importance of early imaging to determine auditory nerve status in children with ANSD, especially when the presentation is unilateral.

Category: Pediatric Audiology / Otology

Poster #: 064

Does Short-Term Implicit Voice Familiarization Improve Children's Speech-in-Noise Recognition?

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Objectives: The goal of this study was to evaluate the extent to which implicit voice familiarization via an interactive computer game can improve children's ability to recognize words presented in classroom noise. It is well established that children have more difficulty than adults when understanding speech in multitalker environments. Recent research on the effects of talker familiarity for children in these contexts is limited and has primarily focused on the benefits associated with long-term implicit voice familiarity or explicit voice

training. However, little attention has been given to how short-term implicit familiarization influences children's speech recognition in noise. The current study examines whether passive short-term voice exposure acquired during a fun and interactive computer game can improve children's speech recognition in noise. A secondary goal of the study was to examine the feasibility of voice familiarization using an interactive computer game. We hypothesized that children's word recognition would improve for target words spoken by the voice they were exposed to during 5-days of interactive game play, regardless of whether the same words had been heard during game play or not.

Design: Children's (8-12yrs) word recognition was measured pre- and post- voice familiarization using the Word Intelligibility by Picture Identification (WIPI) test presented in classroom noise. Target words were spoken by two female talkers, one talker the children would be familiarized with, and one talker would remain unfamiliar. Following pre-test, children were given a take-home computer game, over-the-ear headphones, and a soundcard to use during gameplay. Children played the game for 10 min/day for 5 days. During the game, which was designed specifically for the current study, children heard one voice ("familiar talker") instructing them to move their avatar to pictures associated with words from 2 WIPI lists. Children then returned to the lab for the second word recognition test. To evaluate the benefit of voice familiarity and to test for generalization effects, four conditions were tested (pre- and post-gameplay): (1) familiar talker, familiar words, (2) unfamiliar talker, familiar words (3) familiar talker, unfamiliar words, and (4) unfamiliar talker, unfamiliar words. Information regarding attitudes and experiences with the interactive game was also collected.

Results: Preliminary results indicate children's speech recognition in classroom noise improved for conditions with the familiar talker/familiar words (condition 1) and familiar talker/unfamiliar words (condition 3). Less improvement was observed for the unfamiliar talker conditions. Importantly, there was no overall improvement for the unfamiliar talker/unfamiliar words (condition 4). In addition, all children reported the voice familiarization game was easy and engaging to play.

Conclusions: These initial findings suggest that children's speech-in-noise recognition may be improved by short-term implicit voice familiarization. Furthermore, the data shows that a game could be a useful tool to implicitly familiarize children with a voice. Improvements resulting from implicit knowledge of a talker's voice highlight the importance of knowledge-based factors during children's speech recognition. Given that children have difficulty recognizing speech in noise, implicit voice familiarization may be a viable intervention approach to improve children's communication in noisy classrooms.

Category: Pediatric Audiology / Otology

Poster #: 065

Predictors of Auditory Exposures in the Neonatal Intensive Care Unit

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Objectives: Infants born premature are at greater risk for auditory dysfunction than full-term infants. High noise levels and other adverse acoustic exposures in the neonatal intensive care unit (NICU) have been reported previously. In this study we sought to examine factors that could lead to these adverse exposures, including respiration device, feeding, bed location and bed type (crib vs. incubator).

Design: Data were collected for very preterm (VPT) infants (born ≤ 32 weeks' gestation; $n = 37$) during NICU stay at the Carle Foundation Hospital in Urbana, Illinois. Audio recordings were collected over 24-hour intervals, three times per week for each subject using a LENA recorder. The LENA was adhered to the inside wall of the infant's incubator or crib. Electronic medical record (EMR) data for each infant were documented on an hourly basis by the NICU nurses and staff. We utilized the LENA automated classification algorithm, which labels individual audio segments by sound category (e.g., speech, noise, electronic sounds, silence), and sums the durations of segments of the same category. We analyzed thousands of hours of auditory exposures, with hundreds of hours for each subject.

Results: Preliminary analyses indicate silence exposure is greater for infants in incubators vs. open cribs. In contrast, electronic sound exposure (e.g., alarms) is greater for infants in open cribs. Noise exposure differed across type of O2 device used during respiratory support (e.g., CPAP vs. mechanical ventilator). Daily speech exposure estimates for infants in open cribs averaged approximately 30 minutes per day. Additional analyses are ongoing.

Conclusions: Several factors influence auditory exposures in the NICU, including bed type and nearby medical devices. Whether these factors can be controlled to mitigate adverse auditory exposures remains to be seen. Our results imply that some NICU factors may hinder an infant's exposure to speech during NICU stay. Previous studies have shown that speech exposure during this critical stage of neurodevelopment affects neurobehavioral outcomes. It is hoped that this line of study will lead to interventions designed to prevent audiological impairments associated with preterm birth and NICU environmental exposures.

SPEECH PERCEPTION

Category: Speech Perception

Poster #: 066

Listening Effort and Speech Perception Performance Using Different Facemasks

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Objectives: Facemasks can negatively impact social interaction and introduce difficulties in understanding spoken language. Various types of masks decrease the vocal signal by attenuating high frequencies as much as 3 to 12 dB between 2 and 7 kHz depending on mask type. This attenuation pattern has been compared to a "pseudo hearing impairment," as it mimics the effects of a high-frequency hearing loss. The aim of this research was to assess speech perception performance and listening effort using a variety of facemasks in different signal-to-noise ratios (SNRs). We hypothesized that as listening conditions worsened, either through poor SNRs or due to acoustic effects of the facemasks, greater cognitive demand would be needed resulting in a greater SNR for certain masked conditions and greater perceived listening effort.

Design: Forty adults with normal hearing and hearing loss participated in this study. QuickSIN sentences were recorded in 9 different mask conditions including (1) no mask, (2) surgical mask (SM), (3) KN95, (4) N95, (5) cloth mask with 2 layers (CM2), (6) cloth mask with 3 layers (CM3), (7) transparent mask with a small visual

opening (TM1), (8) transparent mask with a large visual opening (TM2) and, (9) face shield + cloth mask with 3 layers (SHCM3). Two lists of 6 sentences each were recorded for each mask condition. The speech stimuli were presented in the sound field with the presentation level set at 50 dB HL, while the noise level varied from +25 to 0 dB SNR. Participants repeated each sentence and then rated the listening effort they used to hear the sentence using a modified effort rating scale. The listening effort scale ranged from 1 (no extra effort was needed) to 7 (listening effort was maximal).

Results: For listeners with normal hearing, SNR loss scores ranged from normal in some facemask conditions (NM, KN95, N95, SM) to scores that reflected a mild SNR loss (TM1, TM2, CM2) and a moderate SNR loss (CM3, SHCM3). For those with hearing loss, listeners exhibited an SNR loss for all mask conditions (mild for NM; moderate for KN95, SM, TM1, N95, CM2, CM3, TM2; and severe for SHCM3). Listening effort scores were consistent with speech perception performance indicating that when speech perception scores were high, listening effort scores were low and vice versa. As expected, favorable SNRs (20 and 25 dB) had less impact on performance than less favorable SNRs (0 and 5 dB). Analysis of performance and listening effort at +10 and +15 dB SNRs was most useful in determining the impact of specific masks on speech understanding. In general, the masks that resulted in the poorest performance and greatest effort were the transparent and cloth masks, while the best performance and least effort occurred in the no mask, KN95, N95, and SM conditions.

Conclusions: Different facemasks can have a detrimental effect on speech understanding even for individuals with typical hearing. Challenging listening conditions (thicker facemasks and background noise) had a significant impact on speech perception performance and increased listening effort for all participants.

Category: Speech Perception

Poster #: 067

Predictive Context is Helpful, but Retroactive Context is Effortful

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Objectives: The use of context in speech perception is generally thought to be helpful, but has generally been tested in cases where it is used to predict upcoming words rather than repair earlier words. Retroactive use of context has been shown to be effortful while predictive context reduces effort. However, studies that have examined both of these processes have been done with different stimuli, with different listeners, in different paradigms, preventing a fair comparison. Cochlear implant (CI) users exert more effort than normal hearing (NH) listeners to perceive speech, possibly because of the heavier reliance on retroactive context. We hypothesize that there will be an increase in effort when context is used to retroactively recover earlier misperceived words, compared to when context is used to predict upcoming words.

Design: CI and NH listeners heard sentences that were designed so that context could work either forwards or backwards. A single content word was masked by noise either early or late in the sentence. Masked early words could be recovered/repaid with the later context, and masked late words were predictable based on earlier context. Sentence stimuli alternated between these two types and also included fully intact versions with no masked words. During the task changes in pupil dilation were measured as an index of listening effort.

Results: Context reduces effort when it is used predictively, but increases effort when it is used to repair an earlier word, even if intelligibility is perfect. Effort from retroactive use of context persists for several seconds

after the misperceived word, putting later words in jeopardy of being missed. Generally, the duration of the elevated effort lasts longer for the CI listeners, as indicated by NH listeners returning to baseline pupil size faster than listeners with a CI.

Conclusions: The use of context has generally been evaluated only in situations in which it would be predictive, concealing the situations where effort is exerted to use context to repair earlier words. This study provides a novel approach in directly evaluating the mental cost of using context to both repair and predict keywords in a sentence to resolve linguistic ambiguity. The use of context is invisible on percent-correct based measures of speech intelligibility, and therefore is not captured in routine audiological assessment. Lab-based measures of reliance on context should discern predictive versus retroactive use of context, as they are fundamentally distinct processes that have different effects on listening effort.

Category: Speech Perception

Poster #: 068

Topic Awareness Alleviates Listening Effort During Speech Perception

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Objectives: Individuals with hearing loss are more likely to make mistakes or misperceive words during speech perception but they can take advantage of context to retroactively repair these mistakes. Repairing a sentence is a costly and effortful process that potentially hinders the ability to perceive upcoming utterances. However, those observations have been made using sequences of unrelated sentences where the topic changes every stimulus. Conversely, in everyday conversation, listeners build expectations and topic awareness across time, which provides an overarching context to the conversation. We hypothesize that the cost of cognitive repair observed in unrelated sentences will be reduced when individuals are given advance awareness of the topic of an upcoming sentence. We further hypothesize that when topic awareness is not congruent with the upcoming sentence, the processing to repair the sentence may be even more prolonged and effortful.

Design: Individuals with normal hearing and hearing loss heard sentences with a masked target word, requiring listeners to retroactively fill in the missing word using later context. Sentences were either preceded by the presence or absence of a priming word presented visually. There were two types of priming words: 1) Topic word matched to the content of the sentence (facilitating sentence repair) or 2) Topic word unmatched to the sentence (misleading the listener). Listening effort for these sentences was measured by changes in pupil size over time.

Results: Sentences requiring retroactive repair resulted in increased and prolonged pupil dilation. When topic words were related to the upcoming sentence, pupil dilations returned to baseline more quickly following the sentence, suggesting quicker resolution of the ambiguity. When topic words were misleading, pupil dilation increased and sustained for a longer amount of time. Preliminary results suggest that listening effort is prolonged for individuals with hearing loss in comparison to individuals with normal hearing.

Conclusions: Topic awareness can facilitate retroactive repair of a sentence and reduce listening effort for individuals with and without hearing loss. This study represents a transition from describing listening effort to measuring a factor that could help alleviate it, especially for individuals with hearing loss. In the clinic, patients with hearing loss are often given advice to aid in everyday interactions like requesting an agenda prior to a

meeting. The current study provides evidence to support that claim, along with detailed data on the timing of perceived ambiguity and repair. Topic awareness can aid in an individual's ability to follow along in conversations more accurately and quickly while exerting less effort.

Category: Speech Perception

Poster #: 069

Confidence Intervals for Individual Speech-Recognition Test Scores

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Objectives: The objective of this project is to empirically determine confidence intervals for individual word-recognition scores for 25-item and 50-item monosyllabic word tests presented in open-set and closed-set paradigms to normal-hearing and hearing-impaired listeners and to compare the confidence intervals to those predicted by the binomial distribution.

Design: Four equivalent 25-word lists were constructed from recordings of NU-6 monosyllabic words (Department of Veterans Affairs, 2010, Disc 4.0 female talker) with published item-difficulty data. All 100 words were presented to 10 normal-hearing and 16 hearing-impaired listeners at six and five levels for normal and hearing-impaired listeners, respectively, in open-set and closed-set paradigms, resulting in 560 25-word open-set scores and 280 50-word open-set scores and the same numbers of closed-set scores. Confidence intervals (80%, 90%, and 95%) were determined empirically by adjusting a best-fit second-degree polynomial to capture the desired proportion of scores.

Results: Interlist correlation coefficients exceeded 0.9 for 25 and 50 word scores indicating a high degree of reproducibility. The high correlations indicate that responses to the test stimuli are highly dependent, violating the independence requirement of binomial-distribution estimates of variability. Consistent with the high level of inter-dependence of scores, confidence intervals were substantially narrower than those estimated by the binomial distribution.

Conclusions: The results indicate that 25-word scores are substantially more powerful for detecting differences in scores than confidence intervals based on the binomial distribution indicate. The binomial distribution applies to independent observations whereas responses to speech stimuli are highly correlated. As a result the binomial distribution overestimates within-subjects variability of word-recognition scores.

Category: Speech Perception

Poster #: 070

Within- and Across-Session Learning for Native and Non-Native Matrix Sentences

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Objectives: Listeners demonstrate rapid improvements in recognition when presented with challenging or unfamiliar speech stimuli, including non-native accented speech. This study was designed to evaluate recognition and learning for a corpus of matrix sentences recorded by a highly variable set of native and non-native English talkers. Learning was examined both within and across listening sessions, with the hypothesis that a faster rate and larger magnitude of learning would be observed for the non-native as compared to the native stimuli. Rate of learning was also compared across sessions, and hypothesized to slow over time.

Design: Stimuli were recorded from a set of 60 talkers, including 44 non-native English talkers from 13 different language backgrounds. Sentences were mixed in noise- and babble-type maskers, at two signal-to-noise ratios (SNRs) per masker. Eight native English, normal-hearing listeners were recruited to participate in the study. Each participant completed 15 total blocks of 50 trials over the course of 4-7 listening sessions, self-selecting how many blocks to complete per session. Order of presentation within and across blocks was completely randomized with regard to talker type, masker, and SNR.

Results: 1) **Across-Block Learning:** Preliminary analyses reveal overall higher performance for the native sentences as compared to the non-native stimuli, and increasing recognition scores with additional listening. However, the pattern of improvement over blocks appears similar regardless of talker type. 2) **Across-Session Learning:** As listeners completed different numbers of blocks per test session, the stability of learning across sessions was also evaluated by comparing the first and last blocks from each session. As all listeners took at least four sessions to complete all fifteen blocks, the performance in the first four sessions was used for this analysis. A preliminary generalized linear mixed-effects regression (GLMER) indicates that performance was significantly higher at the start of Session 2 as compared to the end of Session 1. This was true regardless of talker type. Additionally, performance did not decline between the end of Sessions 1, 2, and 3, and the start of the subsequent session, indicating stability across sessions. 3) **Within-Block and Across-Session Learning:** The rate of learning within a single block of 50 trials was examined for the first blocks of the first four sessions. A GLMER was fit to the data including a linear predictor for trial number. This model showed that the rate of learning was steepest in Session 1. Additionally, steady across-session improvements were observed for non-native stimuli, while listeners showed a plateau with the native stimuli.

Conclusions: Listeners showed both short term and long term improvements for this closed set of native and non-native matrix sentences. The largest improvements were seen within the first block of listening, with the rate of initial learning not dependent on talker type. These findings indicate that listeners can both attain rapid adaptation to an unfamiliar non-native speech stimulus, and maintain their learning for these stimuli over several days of testing. This suggests that a highly variable sentence set can be beneficial in facilitating long-term learning for non-native English speech.

Category: Speech Perception

Poster #: 071

Prosodic Cues Signaling Information Correction in Utterances

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Objectives: Prosody is used to mark important information in speech. While a listener may correctly perceive the words spoken by a talker, it is possible to still miss the meaning of these words because the listener could not perceive emphasis on a certain word. This could be the difference between hearing "there's a meeting on Friday" as a correction in the day (Friday instead of Tuesday) rather than a correction in the activity (meeting instead of lunch). Misperception of emphasis such as this could result in mistaken actions and negative social judgement of competence, among many other potential consequences. There is good reason to believe that perceptual access to the acoustic cues for word emphasis are affected by hearing loss; however, there is currently no clinical assessment for perception of those cues. This study is on the acoustics of word emphasis in sentences, as well as the development of a new paradigm for assessing perception of those cues beyond simple word intelligibility.

Design: Stimuli consisted of spoken sentences where one word was emphasized in a manner that indicated that a previous sentence was incorrect in a specific way. The emphasized word was systematically moved to different positions within the sentence across trials. Acoustic measures of voice pitch contour, intensity, duration, and vocal quality were observed to characterize how contrastive stress was realized by word position in the utterance. For measures of perception of this cue, participants used a visual analog scale to mark the timing and degree of emphasis on word(s) in the utterance.

Results: Compared to sentences with no particular word being emphasized, sentences with an emphasized word contained increased pitch contour, duration, and intensity at the time of this information, to different degree depending on the position of the word in the sentence. All sentences have inherent decline in all of these features across the course of the utterance, particularly for pitch - meaning that cues to sentence stress are always contextualized relative to position-specific patterns, rather than being fixed acoustic landmarks. Following the word marking a correction, there are numerous ways that a talker signals the end of novel information, including decreased pitch, intensity, and duration of words, as well as rapid shift toward creaky voice quality. Use of visual analog scales to quantify listeners' perception provide granularity in assessment of listener recognition of these cues, in comparison to all-or-none measures that might be insensitive to perceptual difficulties posed by hearing loss.

Conclusions: Emphasis of words in sentences is a complex acoustic phenomenon that cannot be assessed by measuring intelligibility of isolated words nor conventional sentence-length testing materials that lack specific word-level focus. However, emphasis in speech is ubiquitous, so our clinical assessment of speech recognition is unfortunately incomplete without assessment of perceived emphasis. The current study provides a look into the nature of the acoustic cues to be perceived as well as a paradigm that can be suitable for assessment.

Category: Speech Perception

Poster #: 072

Auditory-Visual Speech-in-Noise Recognition with Visual Distraction

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Objectives: Speech-in-noise tasks provide information about listeners' speech understanding in the auditory domain. However, real-world communication environments provide listeners with visual and auditory cues. It has been demonstrated that speech recognition improves when listeners have access to visual cues. However, research to date has not examined how distracting visual information affects speech understanding. The present study aimed to examine performance on a novel visual distraction condition of an auditory-visual speech-in-noise task, the Connected Speech Test (CST). Additionally, the present study aimed to evaluate the relationship between CST performance and performance on auditory and visual selective-attention tasks. It was hypothesized that performance on the CST with visual distraction would be poorer than performance on the CST without visual distraction. It was also hypothesized that individuals who performed better on auditory and visual selective attention tasks would perform better on the CST, with young adults performing better than older adults.

Design: Thirty young adults 18-34 years and ten of thirty older adults 67-82 years were recruited from the Columbus, Ohio area. Participants were recruited from undergraduate courses at The Ohio State University and via ResearchMatch, an online research participant recruitment network. Recruitment for the older adult is ongoing. The CST (an auditory-visual speech-in-noise task) both with and without visual distractions was used to measure speech-in-noise performance. Background visual information was added to increase ecological validity of the assessment. Visual selective-attention was evaluated using the Stroop color word task and the Erikson Flanker task. Auditory selective-attention was evaluated using a dichotic CVC word task with both nonsense and meaningful tokens in free recall and directed recall conditions. CST performance was compared to performance on a dichotic word recognition task and to performance on the Stroop and Flanker tasks.

Results: Across both groups, performance on the CST with visual distraction ($M=73.15$ RAU, $SD=17.29$ RAU) was significantly poorer than performance on the CST without visual distraction ($M=79.24$, $SD=16.68$); $t(39)=5.976$, $p<.001$, $d=.969$. There was a significant difference between age groups in mean CST performance in both the visual distraction condition ($t[39]=2.13$, $p=.04$, $d=.847$) and the no distraction condition ($t[39]=3.16$, $p=.002$, $d=1.256$). A bivariate correlation across age groups revealed a significant negative correlation between Stroop response latency and CST with visual distraction ($r=-.462$, $p=.004$), such that participants with longer Stroop response latencies exhibited poorer CST performance. Additionally, the number of intrusions during the dichotic words directed recall condition was correlated with improvement in CST performance when the visual distractor was removed ($r=.406$, $p=.011$).

Conclusions: Results demonstrate that performance on speech-in-noise tasks is poorer with increased age and with the addition of a visual distractor. This result suggests that real-world speech understanding is likely worse than an auditory-only measure of speech-in-noise. Results also demonstrated that poorer performance on auditory and visual selective-attention tasks was correlated with poorer performance on the CST with visual distraction. If auditory and visual selective-attention abilities are correlated with performance on ecologically valid speech recognition tasks, perhaps selective-attention training could lead to improved speech recognition in real-world listening environments.

TINNITUS

Category: Tinnitus

Poster #: 073

Sex-Specific Prevalence, Demographic Characteristics, and Risk Factors of Tinnitus in the Hispanic Community Health Study/Study of Latinos

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Objectives: Our primary objective was to determine the prevalence of any tinnitus and chronic tinnitus among included participants in the Hispanic Community Study/Study of Latinos (HCHS/SOL). We additionally sought to estimate the relationship between risk factors and occurrence of chronic tinnitus, and to investigate whether sex-specific differences in tinnitus prevalence and/or risk factors were evident.

Design: This cross-sectional analysis used data collected from 2008 to 2011 as part of the HCHS/SOL baseline visit. Individuals who provided responses to tinnitus questions as part of a hearing health history questionnaire were included in the analysis (n = 15,768). Prevalence and multivariable logistic regression were conducted using sampling weights and clustering adjustments for survey design. For estimation of risk factors, the primary outcome of interest was self-reported chronic tinnitus, defined as lasting > 5 minutes at a time, and at least once per week. We hypothesized that after adjusting for covariates known to relate to hearing loss, the risk factors of depressed and anxious symptoms, smoking, hypertension, and noise exposure would be associated with higher odds of chronic tinnitus.

Results: Unstratified prevalence for any occurrence of tinnitus was 32.9% and for chronic tinnitus was 12.1%. When prevalence was stratified by sex, 2995 females (36.4%) and 2187 males (29.0%) reported any occurrence of tinnitus, and among these individuals a subset of 1043 females (12.7%) and 870 males (11.5%) reported chronic tinnitus. The final regression model adjusted for covariates revealed that a 1-unit increase in depression and anxiety symptomology screeners and positive history of recreational noise exposure were associated with higher odds of chronic tinnitus in females (ORs=1.06, [CI:1.04-1.07]; 1.02, [CI:1.01-1.04]; and 1.40, [CI:1.20-1.62]) and in males (ORs=1.06, [CI:1.03-1.08]; 1.05, [CI:1.02-1.08]; and 1.30, [CI:1.05-1.65]). Current smoking was a risk factor for chronic tinnitus in males only (OR=1.53, [CI: 1.16-2.02]).

Conclusions: To our knowledge, this study was the first to report tinnitus prevalence in a large sample of U.S. adults from varied Hispanic/Latino backgrounds. Our findings revealed that prevalence for any tinnitus was higher in the HCHS/SOL than in previously studied US populations. As tinnitus is frequently a symptom of hearing loss, it is important that public health messaging for the Hispanic/Latino community include information describing tinnitus, as well as suggesting hearing testing and/or intervention for those experiencing chronic tinnitus.

Category: Tinnitus

Poster #: 074

Sound Therapy Effect in Tinnitus Sufferers Experienced Sudden Hearing Loss

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Objectives: Tinnitus is one of the typical symptoms observed in sudden hearing loss patients. According to several previous studies, the majority of patients with sudden hearing loss who completed treatment for hearing difficulties returned to the hospital complaining of difficulties with tinnitus. Sound therapy is considered as a treatment option for tinnitus relief. Although many sound therapy studies on tinnitus sufferers have shown significant tinnitus relief, case reports on patients who experienced sudden hearing loss have been very limited. Moreover, patients with sudden hearing loss have been reported to be included in general hearing loss patients, so the effect of sound therapy on these patients is unclear. The present study aimed to measure the effects of sound therapy on tinnitus patients who experienced sudden hearing loss.

Design: Fifteen chronic tinnitus participants who experienced sudden hearing loss were subjected to mixing point-based sound therapy for 3 months. Sound therapy was performed using an earphone and a self-developed application. Participants evaluated the change in hearing before and after sound therapy in a soundproof room. The effect of sound therapy was determined according to the changes in the visual analog scale for loudness, anxiety, and the Korean version of the tinnitus primary functional questionnaire score between a baseline and 3-month time points.

Results: All subjects showed no changes in hearing before and after sound therapy for 3 months. The visual analog scale for loudness decreased from 68.85 to 53.08, and the visual analog scale for anxiety decreased from 65.38 to 50.77, and statistical analysis showed these changes were significant ($t = 2.189$, $p = 0.049$; $t = 2.296$, $p = 0.041$). The K-TPFQ decreased from 65.35 to 49.35 and was also significantly decreased ($t = 4.078$, $p = 0.002$).

Conclusions: This study showed that sound therapy is helpful in relieving tinnitus in patients with tinnitus who experienced sudden hearing loss. In addition, the subjects showed tinnitus relief without further hearing loss. Using these results, hearing professionals can recommend mixing point based sound therapy as a treatment for patients with sudden hearing loss who have been treated for hearing loss but still have difficulties with tinnitus.

Category: Tinnitus

Poster #: 075

Impact of Daily Sound Therapy Duration on Tinnitus Relief

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Objectives: Sound therapy has been considered as a treatment option for people with subjective tinnitus. Many sound therapy studies have reported that some but not all participants showed significant tinnitus relief after receiving this treatment. Therefore, determining the factors that affect the effect of sound therapy is important for improving the effectiveness of sound therapy. The duration of sound therapy appears to improve its effectiveness. Several studies have generally reported that the longer the duration of sound therapy, the greater the tinnitus relief effect. Although the relationship between the duration of sound therapy and tinnitus relief has been confirmed in previous studies to a certain degree, the relationship between the daily sound therapy duration and tinnitus relief remains unclear. The present study aimed to measure the tinnitus relief effect according to daily sound therapy duration.

Design: Forty-three chronic subjective tinnitus participants were randomly assigned to three groups according to the duration of daily sound therapy (1, 3, and 5 h groups), and mixing point-based sound therapy was performed for 3 months. Participants performed sound therapy using a self-developed sound therapy application and headphones. Daily sound therapy durations were recorded via a data-logging system that came with the application. In each group, the efficacy of sound therapy was determined based on changes in the tinnitus loudness level, a visual analog scale of loudness score, the Korean version of the tinnitus primary function questionnaire score, and the effect size of the difference between the baseline and 3-month time points.

Results: As a result of group differences, it was found that the longer the daily sound therapy duration, the greater the sound therapy effect in most measures. The tinnitus loudness level was found to decrease with longer duration of daily sound therapy. The visual analog scale for loudness score and the Korean version of tinnitus primary function questionnaire scores also improved for longer daily sound therapy durations. For the effect size, the 1 hour group showed no clinical effects or small effects. The 3 hour group mostly showed moderate effects and 5 hour group showed large effects in all measures.

Conclusions: This study showed that the tinnitus relief effect can be increased with a longer daily sound therapy duration. Therefore, the duration of daily sound therapy may be a factor that affects the effectiveness of sound therapy. Using these results, hearing professionals can recommend the appropriate daily sound therapy duration when considering sound therapy for tinnitus patients.

ANATOMY and PHYSIOLOGY

Category: Anatomy and Physiology

Poster #: 076

Ear Level Cooling and Intracochlear Temperature Modulation

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Objectives: We have previously demonstrated that ear level cooling using either temperature-controlled water or an earbar attached to a Peltier device can confer otoprotection from cisplatin induced damage. It is also well

documented that mild hypothermia can protection against noise induced hearing loss. Here we examine a novel method of ear cooling in human temporal bones.

Design: Custom earmolds attached to a Peltier device (You Tune Hearing Protection) were used to cool 3 temporal bones with external ears attached and compared to cooling using cool water (ICS Caloric Irrigator). The temporal bones were retrieved from the anatomy lab with external ears intact. The otic capsule was exposed via a middle cranial fossa approach and temperature probes (Physitemp) were placed at the basal turn and apex of the cochlea and sealed with bone wax and dental cement. Placement of probes was confirmed with microCT scans. The temporal bones were maintained at 37°C using a metallic bead bath. After achieving euthermic temperature, external ears were cooled with water and earmold attached to Peltier device.

Results: We observed significant changes in intracochlear temperatures with both water and earmold applied cooling.

Conclusions: Ear leveling cooling can achieve changes in cochlear temperature consistent with mild therapeutic hypothermia.

Category: Anatomy and Physiology

Poster #: 077

Method to Measure Ear-Canal Geometry from Human Temporal Bone CT Scans

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Objectives: Description of the ear canal's geometry is important to understand peripheral sound flow as well as the specific application of wideband acoustic immittance (WAI) measurements, which depend on ear-canal geometry. Yet, there are few studies that directly describe canal geometry. WAI measures, a potential non-invasive diagnostic tool for auditory pathologies, require ear-canal area as a parameter used to calculate reflectance or absorbance; the two existing FDA approved systems each use an assumed constant ear-canal area (44mm² for Mimosa's HearID and 50mm² for Interacoustic's Titan). Recent measurements suggest that average adult ear canals are systematically larger at the probe location than these industry-chosen areas, by an average factor of about 1.3.

Design: A method was developed to measure the ear canal's length and cross-sectional area from high-resolution thin cut temporal bone CT scans. Using the medical imaging software OsiriX, multiplanar reconstructions of CT images were used to measure length as a spline mapped through the center of the canal. Cross-sectional area was measured perpendicular to the canal, along its length, in 1-2mm increments. Using tools within OsiriX, at each location along the canal, a plane perpendicular to both the canal's axial and coronal CT images was defined, and the cross-sectional area and the center point of the canal were recorded at each location. De-identified CT scans were obtained retrospectively through the University of Massachusetts Medical School; both they and Smith College granted exemptions from IRB oversight.

Results: Measurements were made on 6 ears from the CT scans of 3 subjects. For each ear, three independent researchers ("technicians") made blinded area and length measurements to test the repeatability of the method. Average area differences and correlations were calculated for each pairwise comparison of technicians using $n = 112$ measurements starting 4mm lateral from the tympanic membrane and extending to the lateral end of the ear canal. The average difference in areas ranged between 0.44 and 1.48mm² with standard deviations for these differences ranging from 3.46 to 4.60mm². The pairwise correlations were high: 0.98 to 0.99. Across the 6 ears and measurements from all technicians, areas at the first bend ranged from 37 to 91mm², and canal lengths ranged from 29 to 40mm. Area functions and spline curves along the canal lengths were similar for a given subject's left and right ears and differed far more across subjects. These preliminary results from 3 subjects suggest longer ear canals and larger cross-sectional areas than previously published work. These differences could result from the newer capability of multiplanar reconstruction techniques via high-resolution CT scans; prior work with CT scans only employed images from the sagittal plane.

Conclusions: Multiplanar CT reconstruction was used to support a new and repeatable method to describe ear-canal geometry. Application of this method to a larger population of subjects of all ages will enable a far better description of individual ear-canal geometry as well as variability across subjects. Furthermore, descriptions of ear canals of all ages will support the development of accurate WAI measurements.

AUDITORY PROCESSING

Category: Auditory Processing

Poster #: 078

Combined Exposure to Jet Fuel and Background Noise Produces Central Compensation in the Auditory System

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Objectives: To test the hypothesis that combined exposure to jet fuel and background noise will induce central compensation (central gain) in the auditory system.

Design: The auditory brainstem of pigmented rats was used as a model system. The animals were randomized into the following experimental groups ($N = 5$ per group): Fuel+Noise, fuel-only, noise-only and control. Ascending volume conductance from various auditory brainstem regions were evaluated simultaneously with peripheral nervous system input to brainstem circuitry.

Results: The results revealed normal peripheral nervous system for all groups. However, Fuel+Noise exposure produced statistically significant ($p < 0.05$) lower neural responses in the caudal brainstem which was accompanied by neural responses in the rostral brainstem that approximated that of normal (control). This rostral (central) compensation effect was specific to Fuel+Noise exposure, since neither noise-alone or fuel-alone produced the same result.

Conclusions: Central compensation in the auditory brainstem is consistent with perceptual abnormalities such as poor speech discrimination, tinnitus, hyperacusis and loudness intolerance. Therefore, a potential consequence of Fuel+Noise exposure among military and civilian populations may be increased rates of super-threshold

auditory perceptual abnormalities. This is particularly important because to date, the ototoxic profile of Fuel+Noise exposure has remained unresolved.

Category: Auditory Processing

Poster #: 079

Music Discrimination Impacts Music Enjoyment Among Individuals with Hearing Loss

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Objectives: Hearing aids were traditionally designed for speech, rather than music listening. Moreover, the impact of music discrimination on music enjoyment is not well-studied. Our objective was to examine the association between music discrimination and music enjoyment in hearing aid users while aided and unaided across all ranges of hearing loss. We hypothesized that music discrimination would be independently associated with music enjoyment with and without hearing aids.

Design: A cross-sectional online survey was administered via a computer with speakers to adult (≥ 18 years) bilateral HA users recruited from a community and tertiary medical center setting. Subjects were instructed to actively listen to musical stimuli and rate their enjoyment across three validated measures (pleasantness, musicality, and naturalness) using a bipolar visual analog scale (10 indicates highest level of enjoyment, 1 indicates least level of enjoyment), both with and without their hearing aids. The order of these conditions (i.e., with or without hearing aids) were randomly assigned. Subjects also completed a short demographic survey and musical discrimination task derived from the Montreal Battery for Evaluation of Amusia (MBEA) with hearing aids. Music discrimination was scored as percentage correct on the task. Multivariable linear regression was performed to assess the association between music discrimination and music enjoyment adjust for potential confounders (age, sex, education, race, hearing aid type, age at hearing loss diagnosis, duration of hearing loss, duration of hearing aid use, musical preference, musical experience, and severity of hearing loss. Separate multivariable linear regression models using different measures of hearing loss (pure tone average and word recognition score of the better hearing ear) were employed.

Results: Among 100 subjects, mean (standard deviation [SD]) age was 66.0 (18.0) years; 52% were female. Mean (SD) pure tone average of the better ear was 50.2 (13.5) dB. Twenty-six (26%) subjects had mild HL (PTAB 26-40 dB), 66 (66%) moderate to moderately severe HL (PTAB 41-70 dB), and 8 (8%) severe HL or worse (PTAB ≥ 71 dB). Mean (SD) length of HA use was 13.4 (12.2). Mean (SD) word recognition score of the better ear was 84.5 (16.5) %. Mean (SD) musical experience was 5.04 (8.6) years; 44% had some level of musical experience. Mean (SD) music discrimination score was 69.1 (16.2) % correct. Improved music discrimination was independently associated with increased unaided music enjoyment (pleasantness [estimate 3.948, 95% confidence interval 1.299-6.597], musicality [5.515, 2.946-8.084], naturalness [4.150, 1.252-7.049]), as well as increased aided music enjoyment (pleasantness [3.055, 0.33-5.778], musicality [4.119, 1.262-6.976]) when using pure tone average of the better hearing ear as the measure of hearing loss severity. Improved music discrimination was also independently associated with increased aided and unaided enjoyment when using word recognition score of the better hearing ear as the measure of hearing loss severity.

Conclusions: Among bilateral adult hearing aid users, increased music discrimination is independently associated with increased aided and unaided music enjoyment.

Category: Auditory Processing

Poster #: 080

Self-Rated Spatial Hearing Among Fallers and Non-Fallers with Hearing Loss

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Objectives: Hearing loss has been shown to be associated with increased risk of falling. To date, mechanisms that may explain that association are unknown. Several candidate mechanisms have been proposed and include direct "common cause" aging factors, concomitant age-related vestibular loss, auditory factors such as reduced spatial awareness and increased listening effort, psychosocial factors, and cognitive factors. The purpose of this study was to examine spatial listening in a sample of audiology patients to understand if differences exist between fallers and non-fallers. We hypothesized that individuals with a history of falls would report reduced spatial hearing ability compared to those without a history of falling.

Design: This is a cross sectional survey study that included a random sample of audiology patients evaluated between 2015-2018. Audiology patients were invited to complete a survey that inquired about medical history, falls status, and asked to complete the validated Spatial Hearing Questionnaire and Hearing Handicap Inventory for the Elderly. Two hundred and seventy four individuals agreed to participate and their data was used for the analysis.

Results: Among survey respondents, 198 individuals reported no falls (72.2%), 38 reported a single fall (13.9%) and 38 reported 2 or more falls (13.9%) in the past year. Mean scores ((standard deviations) for the spatial hearing factor of the spatial hearing questionnaire were 71.3 (25.1), 63.2 (25.2), and 57.2 (25.9) for individuals who report no falls, 1 fall, or 2 or more falls in the past year, respectively. An ANOVA revealed a significant difference between the groups; $F(2,271) = 5.78, p = 0.003$. Post-hoc analysis showed that the differences existed between those with no falls and ≥ 2 falls and that those with multiple falls reported poorer spatial hearing factor scores overall. Additional modeling that includes important health-related and hearing related covariates is underway.

Conclusions: Overall, our data suggest that differences exist in self-rated spatial hearing between fallers and non-fallers. Further characterization of performance is needed to fully understand the extent to which decreased spatial hearing may contribute to falls.

COCHLEAR IMPLANTS

Category: Cochlear Implants

Poster #: 081

Effect of EchoBlock on Speech Understanding for Cochlear Implant Users

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Objectives: Reverberation has a significant negative impact on speech understanding for cochlear implant (CI) users. EchoBlock technology has been designed to decrease the effects of reverberation on speech understanding for Sonova Phonak hearing aids (HA) and Advanced Bionics CIs; however, there is limited published research on the effectiveness of EchoBlock. The objective of this study, therefore, was to evaluate the extent to which EchoBlock improves speech understanding in reverberant conditions both in quiet and in noise. It is hypothesized that speech understanding in quiet with reverberation will improve with the use of EchoBlock if it operates similarly to EchoShield. In noise, however, we hypothesize that the results with and without EchoBlock will not differ significantly because the directional microphones are already activated in noise, and reflections from the reverberation cannot be easily separated from other background noise.

Design: Speech perception was measured for 6 Advanced Bionics CI recipients using sentence stimuli that were corrupted by reverberation either in quiet or in noise. Participants were tested with two reverberation times (RT60) in quiet and in noise: RT60 = 0.1 in quiet, RT60 = 0.3 in quiet, RT60 = 0.1 at +15 signal to noise ratio (SNR), RT60 = 0.3 at +15 SNR. All four conditions were tested in random order with and without EchoBlock, for a total of eight conditions. This study was a split-half design, where half of the participants began testing with EchoBlock on and the remaining half began testing with EchoBlock off.

Results: Results indicated no significant effects of EchoBlock status, but there was a significant effect of reverberation time, as expected, where performance was poorer for the longer reverberation time. There was no significant interaction between EchoBlock status and reverberation time. These results were consistent for conditions in quiet and in noise.

Conclusions: The results of the present study, show a significant effect of reverberation time on speech perception, where performance is poorer for longer reverberation times both in quiet and in noise, consistent with the literature. Results show no significant difference in speech perception scores with or without EchoBlock on in both quiet and in noise. It is difficult to draw a conclusion about the effectiveness of EchoBlock based on results of this study alone due to our limited knowledge of the technology behind this feature. Much more research is needed on the effectiveness of EchoBlock before we can accurately begin presenting it to our patients as a tool to assist them when they are in reverberant environment.

Category: Cochlear Implants

Poster #: 082

Communication Profile for the Hearing Impaired: Outcomes for Cochlear Implants

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Objectives: The objective for this study was to examine the extent to which outcomes on the Communication Profile for the Hearing Impaired (CPHI) differed between cochlear implant (CI) users and published data for people with hearing aids (HAs). The CPHI was originally developed for and normed on adults with HAs. It is unclear the extent to which this tool can be used with CI recipients because they may have different experiences with and attitudes toward communication than HA users. The CPHI consists of five categories: communication performance, communication importance, communication environment, communication strategies, and personal adjustment. For each of these five categories we hypothesized that, in relation to HA users, CI users will: 1.

Have similar scores on communication performance because CI users are considered hearing impaired. 2. Have better scores on communication importance, potentially because CI users are willing to undergo surgery to improve their communication. 3. Have similar scores on communication environment because they share challenges across listening environments. 4. Have better scores on communication strategies due to greater severity of hearing loss necessitating greater reliance on the use of communication strategies. 5. Have better scores on personal adjustment due to a higher degree of acceptance of their loss before moving forward with surgery.

Design: Data were collected for 93 adult CI users. Inclusion criteria were a passing score on a cognitive screening test, post lingually deafened, spoken English as the primary language, and no other disabilities that affected their mode of communication. Participants completed the CPHI and results were compared to published data from hearing aid users.

Results: Results for this study indicated that for approximately two-thirds of the subcategories of the CPHI, there were no significant differences between CI users and HA user outcomes. Significant differences were as follows: 1. For communication performance, CI users scored better than HA users in the work and problem awareness subcategories. 2. For communication importance, CI users scored better than HA users in the social and home subcategories. 3. For communication environment, there was no significant difference between CI users and HA users. 4. For communication strategies, CI users had less maladaptive behaviors than HA users, along with better verbal and nonverbal strategies than HA users. 5. For personal adjustment, CI users had less displacement of responsibility, withdrawal, and denial than HA users.

Conclusions: Results from this study generally supported the hypotheses that CI and HA users have similar communication issues in some areas but differ significantly in others. As a result, different normative values should be used for CI recipients.

Category: Cochlear Implants

Poster #: 083

MoCA Outcomes for Normal Hearing versus Cochlear Implants

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Objectives: The Montreal Cognitive Assessment (MoCA) has four test items dependent on the auditory system, potentially leaving hearing-impaired (HI) individuals at a disadvantage. Previous work found that HI individuals perform poorer than normal-hearing (NH) individuals on the MoCA, potentially due to the degraded auditory signals they perceive. Degraded auditory input negatively impacts the ability to commit auditory information to memory. However, there is no research comparing how cochlear implant (CI) recipients perform on the MoCA relative to NH and HI individuals. Therefore, the goal of this study was to 1) compare MoCA scores using the original MoCA scoring method and three additional hearing-adjusted scoring methods between a group of age-matched CI recipients and NH individuals, 2) determine if there was a gap between the two groups in overall scores and hearing-adjusted scores, and 3) compare our CI versus NH data to the comparison between NH and HI individuals reported in the literature. Due to the greater severity of hearing loss and the poor spectral resolution of CIs, we hypothesized that the gap in both overall scores and hearing-adjusted scores

between CI recipients and NH participants would be greater than the gap previously reported between HI and NH individuals.

Design: Existing MoCA data from 94 CI recipients were examined alongside data prospectively obtained from 105 NH individuals. NH participants first underwent a hearing screening to verify NH status. Thirty-one participants failed the hearing screening and were dismissed from the study, leaving 74 NH participants who met the inclusion criteria. The average age of the CI and NH groups were 65.5 years and 58.8 years, respectively. Due to the difficulty in recruiting older NH participants to age-match to the existing CI data, the oldest CI participants were systematically excluded until there was no significant difference in age between groups (61.2 years for a total of 75 CI participants and 58.8 years for the 74 NH participants). Both groups completed the MoCA. Scores were compared between the two groups, as well as to published data, using the original MoCA scoring method and three additional scoring methods that excluded various auditory-dependent test items.

Results: MoCA scores for CI recipients were significantly poorer than those for age-matched NH participants for all four scoring methods. CI recipients scored better than the published data for HI individuals, although those data were not age matched.

Conclusions: Results from this study suggest that performance is not only affected by auditory based factors on the MoCA, but is also potentially affected by the greater cognitive processing required to interpret degraded signals received by CI recipients.

Category: Cochlear Implants

Poster #: 084

Sequential Learning in Children with CIs and Typically Hearing Peers

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Objectives: Sequential learning is a statistical learning mechanism that supports rule-based learning (e.g., grammatical development). Children with cochlear implants (CIs) have demonstrated sequential learning deficits in experimental tasks; however, findings have been mixed due to the heterogeneity of task demands across sequential learning paradigms. The serial reaction time (SRT) task is a paradigm used to study implicit sequential learning in visual, nonverbal contexts. Past work has demonstrated that children with CIs show learning through a reduction in reaction time to implicit, repeated sequences relative to random sequences; however, these children also show longer reaction times to all stimuli relative to typically hearing peers. Recent evidence in children with typical hearing suggests that the degree to which SRT stimuli can be labelled (i.e., verbally mediated) moderates learning of implicitly presented sequences. Furthermore, children with larger vocabularies showed weaker implicit learning for visual stimuli that could be easily labelled, suggesting that use of higher-level, language-dependent strategies hinders implicit learning. The current investigation utilizes SRT sequences with high and low degrees of verbal mediation to 1) compare implicit sequence learning by children with cochlear implants and typically hearing peers, 2) determine if language skills (i.e., vocabulary size, rapid automatic naming skills) affect underlying implicit sequential mechanisms across groups, and 3) to evaluate explicit recall of implicitly learned verbally and nonverbally mediated sequences. We hypothesize that, relative to typically hearing peers, children with cochlear implants will show 1) overall longer reaction times but

comparable implicit learning on a traditional nonverbal SRT, 2) poorer vocabulary skills, therefore better implicit learning on a verbally mediated SRT, and 3) no differences in explicit recall of implicit SRT sequences.

Design: Twenty-five 7- to 15-year-old children with cochlear implants and aged-matched typically hearing peers will complete testing. Participants complete a baseline motor task using the SRT button apparatus, visual nonverbal and verbally mediated SRT tasks, visuospatial memory span tasks using sequences of stimuli from both SRT tasks, and a questionnaire addressing verbal strategy use during sequential learning tasks. Participants complete each memory span task immediately following each SRT task, and the presentation order of SRT tasks is counterbalanced across participants. Participants additionally complete standardized measures of nonverbal intelligence (WASI-II Matrix Reasoning), expressive vocabulary (EVT-2), visuospatial short-term memory (CABC Location Span), and rapid automatic naming (CTOPP-2 rapid naming tasks); general executive function is assessed via parent report (BRIEF).

Results: Pilot data have been collected for 25 children with typical hearing and four children with CIs. All participants completed the verbally and nonverbally mediated SRT tasks; therefore, we can be confident that children with CIs will be able to complete the task. Data collection and analysis are in progress and will be completed by February 2022.

Conclusions: If language skills robustly moderate performance on a verbally mediated SRT task, these findings suggest that general statistical learning mechanisms and higher-order, language-dependent mechanisms operate in competition. Such findings support normalizing task demands within sequential learning paradigms to account for language-dependent confounds (e.g., verbal mediation), especially as language-dependent learning mechanisms may be underdeveloped in children with hearing loss.

Category: Cochlear Implants

Poster #: 085

Frequency Following Response and Speech Perception in the Pediatric Population

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Objectives: Although cochlear implantation is indicated as early as 9 months of age for children with bilateral severe-to-profound sensorineural hearing loss, the decision between bilateral cochlear implantation and bimodal listening (cochlear implant (CI) + hearing aid (HA)) is not clear-cut at such a young age before behavioral testing is possible. Furthermore, bimodal benefit cannot be predicted based on audiometric thresholds alone, or even with current clinical speech perception measures. An objective measure with potential for clinical application in the determination of listening configuration is the frequency following response (FFR). The FFR is a neurophonic auditory evoked potential that quantifies neural processing of speech characteristics including periodicity and temporal fine structure. Numerous studies have demonstrated a relationship between FFR amplitude and behavioral speech perception ability in adults with normal hearing and with hearing loss. Furthermore, one study demonstrated a significant correlation between FFR representation of fundamental frequency (F0) and bimodal benefit in adult CI users, indicating that the FFR may be useful in guiding device selection. There are fewer studies in the current FFR literature examining the pediatric population, although the FFR is present and robust in infancy, suggesting that it may prove useful in device selection for prelingual children. Thus the current study aimed to investigate the relationship between FFR and speech perception in children with normal hearing and children using a bimodal hearing configuration. We hypothesized that there

would be a significant relationship between FFR F0 amplitude in the non-implanted ear and bimodal benefit for pediatric bimodal listeners.

Design: At the time of abstract preparation, we had enrolled 5 bimodal listeners with varying degrees of hearing loss in the non-implanted ear and 6 children with normal hearing aged 4-14 years. Participants completed speech perception testing in quiet and noise, psychophysical measures of spectral and temporal resolution, and FFR for a 170-ms /da/ stimulus. Speech perception for bimodal listeners was assessed in HA alone, CI alone, and bimodal (CI+HA) conditions. FFR was completed in one ear (randomized) for children with NH and in the non-implanted ear for bimodal listeners using a magnetically-shielded insert earphone.

Results: Consistent with data from adult bimodal listeners, preliminary data analysis revealed a correlation between FFR F0 amplitude in the non-implanted ear and bimodal benefit for monosyllabic word recognition ($r = 0.90$) and sentence recognition in noise (+5 dB signal-to-noise ratio) ($r = 0.67$)-even when controlling for audiometric thresholds in the non-implanted ear. Analyzing data across normal hearing and bimodal hearing listeners, we observed a strong, positive correlation between age and FFR F0 amplitude ($r=0.67$) and speech recognition in noise ($r=0.44$), consistent with well-described developmental effects. Data collection for psychophysical measures of spectral and temporal processing was not yet complete at the time of abstract preparation.

Conclusions: Consistent with previous studies, these data suggest potential clinical utility of the FFR in estimating degree of bimodal benefit. This objective measure may ultimately guide clinical recommendations regarding device configuration in young children unable to complete behavioral speech recognition tasks; however, additional data collection is necessary prior to determining clinical application.

Category: Cochlear Implants

Poster #: 086

Spectral Degradation Reduces Verbal Sequence Learning in Children

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Objectives: Spoken language outcomes in children who are deaf with cochlear implants (CIs) tend to vary post-implantation. Two factors that may contribute to their variable degrees of success include: a degraded auditory signal; and a period of auditory and linguistic deprivation prior to implantation that could affect cognitive processes used for language. One type of cognitive process important for learning language is verbal sequence learning. The objective of this study was to investigate the peripheral and cognitive factors that affect language learning in children with CIs. Specifically, we investigated 1) the extent that a spectrally degraded auditory signal impacts verbal sequence learning in children with typical hearing (TH) and 2) how learning performance in children with CIs compares to children with TH. Based on our preliminary and published work, we hypothesized that children with TH may show intact sequence learning with vocoded input but that children with CIs may show less learning compared to their age-matched peers with TH.

Design: Nineteen native-English speaking children with TH (7-12 years) and one 10-year-old child with bilateral CIs participated. Auditory-verbal sequence learning was assessed using a version of the Hebb

repetition paradigm in which participants listened to sequences of five consonant-vowel-consonant non-words and then were asked to immediately verbally reproduce each sequence. Every third sequence was repeated; learning was operationalized as greater recall for repeated sequences (12 total) compared to random sequences (25 total). Children with TH were presented with both an 8-channel vocoded condition and an unprocessed condition, while the child with CIs was presented with the unprocessed condition only.

Results: Responses were scored based on phonemes correct. Children with TH correctly recalled an average of 8.6% and 6.1% more phonemes for repeated sequences than random sequences in the unprocessed and vocoded conditions, respectively. Overall, the learning effect in the vocoded condition was similar to the unprocessed condition, with statistically significant greater recall accuracy for the repeated sequences than random sequences (Signed rank test, $p < .01$). A considerable amount of learning was also achieved for the child with CIs, with 34% more words recalled for repeated sequences than random sequences.

Conclusions: Our results suggest that verbal sequence learning occurs in children with TH regardless of auditory quality. Compared to a preliminary experiment with adults using the same paradigm, children showed about half the amount of learning. Based on the data of the participant with CIs, we see high levels of sequence learning. However, this result should be taken with caution as this participant scored exceptionally high on the Quick Spectral Modulation Detection task and will likely be a sample outlier. Additional assessment of children with CIs is needed. However, if our expectations are correct, and we find variability in sequence learning in children with CIs, then it may be that there are differences in how these children are learning and processing information and degraded auditory input alone would not explain the observed variability in spoken language outcomes.

DIAGNOSTIC AUDIOLOGY / OTOTOLOGY

Category: Diagnostic Audiology / Otology

Poster #: 087

Association Between Adult-Onset Hearing Loss & Income: A Systematic Review

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Objectives: Hearing loss has been shown to be associated with both negative health outcomes and low socioeconomic position, including lower income. Despite this, a thorough review of the existing literature on this relationship has not yet been performed. Current literature uses diverse methodologies, demonstrates varying results, and is largely homogenous in study design. Therefore, we specifically sought to examine the potential association between hearing loss and income among individuals with adult-onset hearing loss.

Design: A search was conducted in eight databases for all relevant literature using terms focused on hearing loss and income. Manuscripts reporting the presence or absence of an association between income and hearing loss; full-text English-language access; and a predominantly adult population (≥ 18 years old) were eligible. The Newcastle-Ottawa quality assessment scale was used to assess risk of bias.

Results: The initial literature search yielded 2,994 references with 3 additional sources added through citation searching. After duplicate removal, 2,355 articles underwent title and abstract screening. This yielded 161 articles eligible for full-text review resulting in 46 articles that were included in qualitative synthesis. Of the included studies, 41 out of 46 articles found an association between income and adult-onset hearing loss. Of the highest quality studies which were nationally representative, controlled for education, and had a primary focus on income and hearing loss ($n=7$), six found an association between income and hearing loss. The settings of the included studies were examined, with 31 countries represented across the 46 manuscripts. The majority ($n=36$) were carried out in high-income countries. Data regarding race or ethnicity was only measured in nine studies but in these, inclusion of participants who self-identify with a racial or ethnic minority group was limited. Sex/gender differences in the association between income and hearing loss was also examined in nine studies, four of which found the association to be greater for men or males, three finding the association to be greater for women or females, and two findings no association.

Conclusions: The available literature consistently supports an association between income and adult-onset hearing loss but is limited entirely to cross-sectional studies and directionality remains unknown. While there were a wide variety of countries represented in this review, there was a notable absence of sufficient data on ethnicity. Often, sex and gender were often used interchangeably among included studies. As such, these papers lacked clarity in whether they were measuring sex or gender identity differences and highlight the need for greater precision in examining sex and/or gender-based differences. Limitations to this review include that hearing loss and income lacked uniformity across studies; data from low-income countries was absent; and study design homogeneity. Ultimately, more research is needed in 1) gathering longitudinal data, including studies based within low-income countries to better understand the mechanisms underlying this relationship and 2) determining ways to reduce or eliminate the potential socioeconomic effects of hearing loss. An aging population and the negative health outcomes associated with hearing loss, emphasize the importance of understanding and addressing the role of social determinants in the prevention and management of hearing loss.

Category: Diagnostic Audiology / Otology

Poster #: 088

Health Literacy, Hearing Loss, and Audiologic Measures of Speech Recognition

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Objectives: Health literacy refers to the degree to which patients have the ability to obtain, process, and understand basic information and services needed to make appropriate decisions regarding their health. Inadequate health literacy places patients at risk for reduced access to healthcare, and poorer quality of care when they receive it. We have previously demonstrated that patients with inadequate health literacy have worse hearing thresholds on average than patients with adequate health literacy when first presenting to the clinic.

Adoption of hearing aids was not affected by health literacy, however. Rather, severity of hearing loss and hearing aid coverage by insurance were significant drivers of hearing aid adoption. While this information is useful, there remain several unanswered questions with regard to health literacy and hearing healthcare. One key factor is the extent to which performance on audiologic tests of speech recognition is associated with health literacy. This may be particularly relevant as the field transitions to more complex tests of speech recognition in noise. In some instances, such measures may be more complex linguistically than monosyllabic word recognition, raising the possibility that the same factors associated with poor health literacy may also influence speech-recognition abilities. Here we addressed this issue by examining the association between health literacy, and performance on tests of word-recognition in quiet (WRQ) and speech-recognition in noise (SIN).

Design: Data were obtained retrospectively from patients undergoing audiometric assessment at Stanford University. 1825 patients completed a brief health-literacy questionnaire in addition to their routine audiometric assessment. Health literacy was determined by the Brief Health Literacy Screen, which is a validated 3-item questionnaire. The responses were scored, and patients were classified as having adequate or inadequate health literacy. Of the 1825 patients who completed both pure-tone audiometry and a health literacy questionnaire, 975 completed both NU-6 lists and the QuickSIN. Of these, 45 had inadequate health literacy, while the remaining 930 were adequate. All tests of speech recognition were presented at levels designed to maximize audibility.

Results: Consistent with our previous results, patients with inadequate health literacy had poorer hearing thresholds on average (32 vs. 23 dB HFPTA). WRQ scores also differed between the two groups (89 vs. 95% correct for inadequate vs. adequate health literacy, respectively), although both groups performed excellently on this task. QuickSIN scores, however, were twice as poor in the inadequate health literacy group (8.6 vs. 4.2 dB SNR loss). Results of a multiple regression suggest that these differences in speech recognition persist after accounting for their degree of hearing loss. Other factors as education level, and racial / ethnic background, and marital status will also be considered.

Conclusions: These results suggest that inadequate health literacy is associated with poorer performance on speech recognition tasks in both quiet and noise. Taken together, these data are consistent with the idea that 1) non-auditory factors can affect performance on routine audiologic measures, and 2) these factors related to the ability of patients to effectively navigate the health system may also influence performance on routine clinical assessment.

Category: Diagnostic Audiology / Otology

Poster #: 089

A Normative Study of Ipsilateral Wideband Acoustic Reflex Growth Function

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Objectives: The acoustic reflex magnitude varies as the activator level increases, known as the acoustic reflex growth function (ARGF). The ARGF tested with single-frequency probe signals was utilized as a noninvasive, objective measure in evaluating integrity of the auditory nervous system at the brainstem level. A wideband acoustic reflex (WAR) procedure has been developed using clicks as probe signals. Previous studies have revealed that WAR threshold testing is superior in clinical applications. No study has systematically

investigated the wideband ARGF. The objective of this study was to characterize wideband ARGFs and acquire normative data in adults.

Design: Data were collected from 65 normal-hearing adults. A Wideband Tympanometry Research System (Interacoustics) was used for ipsilateral WAR tests, which were conducted with five activators: tone bursts (500, 1000, 2000, and 4000 Hz) and broadband noise (BBN). The activator was presented in ascending 5-dB steps (60-105 dB for 500, 1000, and 2000 Hz, 50-95 dB for 4000 Hz, and 45-90 dB for BBN). The wideband ARGF was evaluated with WAR magnitude and its slope. The WAR magnitude was quantified in two measures: absorbance change and relative AR-Level in the presence of an activator. The ARGF slope was calculated using its initial three data points with a linear fit method for the absorbance ARGF at four frequencies (397, 630, 1000, and 1587 Hz) and for the passband AR-Level ARGFs for low frequencies (380-2800 Hz) and high frequencies (2800-8000 Hz).

Results: Preliminary data from 31 ears have been analyzed. The WAR spectrum displayed that the absorbance decreased for frequencies below around 1000 Hz and increased between 1000 Hz and 4000 Hz. The dynamic range of wideband ARGF varied from 25 to 35 dB for tonal activators and up to 45 dB for BBN. Descriptive statistics (mean, standard deviation, and 90% range) of WAR magnitude and the ARGF slope were obtained. A two-way ANOVA was applied to assess the effect of probe frequency and activator on the wideband ARGF. The effect of activator level on absorbance change at four probe frequencies was significant for the five activators and the effect of probe frequency across the activator levels was significant for the 1000- and 2000-Hz activators ($p < 0.05$). The absorbance ARGF at 630 Hz had significantly steeper slopes than that at the other three probe frequencies for the 1000-Hz, 2000-Hz, and BBN activators ($p < 0.05$). The passband AR-Level ARGF for low-frequency had a significantly steeper slope than that for high-frequency for the five activators ($p < 0.05$). The slopes of the absorbance and AR-Level ARGFs were the shallowest for the BBN. There was no significant slope difference of the absorbance and the AR-Level ARGFs between five activators ($p > 0.05$).

Conclusions: The current research has provided the first set of normative data of ipsilateral wideband ARGF tested with five commonly used activators in adults. Our preliminary results indicate that the slope of wideband ARGF is affected by probe frequency and unaffected by activator frequency. A better understanding of the ARGF across a broad frequency range provides the baseline to the future clinical study on wideband ARGF.

Category: Diagnostic Audiology / Otology

Poster #: 090

Clinical Utility of Wideband Acoustic Immittance Measures and the ETDQ-7 in Eustachian Tube Dysfunction in Tricare Beneficiaries

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Objectives: The eustachian tube equalizes pressure and ventilates the middle ear. In eustachian tube dysfunction, these functions 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 seen commonly in patients presenting at ear, nose, 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,

including 40,000 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 symptom assessment instrument that has undergone initial validation studies; it scores symptoms of eustachian tube dysfunction based on patient-reported symptoms and severity. Some objective tests have been devised to assess the ventilator function of the eustachian tube, but their 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. However, research is limited concerning its clinical utility as a test of eustachian tube dysfunction. Consequently, there is little research using WAI at 0 decapascal and tympanometric peak pressure to evaluate eustachian tube dysfunction. This research study utilizes a cross-sectional design to assess WAI measures and the ETDQ-7 in participants with eustachian tube dysfunction. This study aims to assess the use of WAI and ETDQ-7 to evaluate eustachian tube dysfunction in Tricare beneficiaries.

Design: A cross-sectional study design will assess WAI measures and the ETDQ-7 in participants with eustachian tube dysfunction. WAI measures will be completed at 0 decapascal and tympanometric peak pressure.

Results: Results from participants enrolled in the study to date will be analyzed using descriptive statistics, t-tests, and F-tests.

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

Category: Diagnostic Audiology / Otology

Poster #: 091

Averaging Effects on Medial Olivocochlear Reflex Assessed by Otoacoustic Emissions

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Objectives: Medial olivocochlear (MOC) reflex when assessed by transiently evoked otoacoustic emissions (TEOAEs) is a very small effect. Therefore a crucial matter is to obtain signals of the best quality, i.e. with sufficient signal to noise ratio (SNR) which is bound to number of averages. Despite this fact, most MOC reflex studies are based on default number of averages provided by the measurement system. This study investigated how reliability of MOC reflex changes with number of averages. Additionally the influence of presence of synchronized spontaneous otoacoustic emissions (SSOAEs) was taken into account as it is known that they significantly influence TEOAE amplitudes and SNRs.

Design: TEOAEs were recorded in a group of 43 women with normal hearing. TEOAEs were measured using an ILO 292-II system, software version ILOv6 (Otodynamics Ltd, Hatfield, U.K.). TEOAEs were recorded with a linear protocol (all stimuli at the same level and polarity), a TEOAE stimulus level of 65 dB peSPL, and contralateral broadband noise (60 dB SPL) as a suppressor. Each recording session consisted of two series of

four measurements. Each of the measurements used 250 averages (close to default 260 setting of the system), resulting in summary in 1000 averages (maximum in the system).

Results: The MOC reflex was calculated as raw dB effect, as a normalized % effect of magnitude change, and as a normalized % effect of signal waveform change. The MOC reflex was slightly bigger for ears with SSOAEs. Furthermore the reliability of MOC reflex was also higher for ears with SSOAEs, and changed minimally with greater number of averages. On the contrary, the MOC reflex for ears without SSOAEs had quite low reliability for standard number of averages.

Conclusions: The obtained results show that number of averages for good quality MOC reflex measure should be greater than for standard TEOAE measurement, and it is especially apparent for ears without SSOAEs. It seems reasonable to check for SSOAE presence before making MOC reflex test. Then, the ears with SSOAEs may be tested quite fast, while the ears without SSOAEs should be tested with averaging at least double of the time/number of the default setting.

Category: Diagnostic Audiology / Otology

Poster #: 092

Estimating Conductive Hearing Loss from Wideband Acoustic Immittance Measurements

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Objectives: Wideband acoustic immittance (WAI) measurements have demonstrated clinical utility in the differential diagnosis of otitis media with effusion (OME). Specifically, WAI has been shown to reliably differentiate not only the presence of an effusion, but also its volume. This is important because effusion volume has been shown to drive the amount of conductive hearing loss (CHL) that results from a given episode of OME. The goal of this work was to determine how well CHL could be estimated directly from measured WAI in ears with OME.

Design: Thirty-four ears from a previously published study on OME were included: 26 ears with OME (with varying effusion volumes) and 8 age-matched healthy normal control ears. Both WAI and air- and bone-conduction audiometric thresholds from each ear were utilized in this work. First, average WAI absorbance across frequency (0.226-8 kHz) was compared to both four-frequency pure-tone average (4PTA, 0.5-4 kHz) and average air-bone gap (ABG, 0.5-4 kHz) in each ear. Then, an electrical-analog model of ear-canal acoustics and middle-ear mechanics was fit to each WAI absorbance measurement to estimate the average conductive hearing loss (CHL) for each ear, and results were compared to measured thresholds. WAI-based model estimates of CHL were initially based on either average absorbance or the component of the model response thought to represent damping in the ossicular chain. Further improvements in CHL predictions were obtained by taking advantage of features discovered in the data.

Results: Average absorbance was strongly correlated with both 4PTA ($r = -0.86$) and ABG ($r = -0.91$), suggesting the potential for CHL to be predicted from absorbance measures. The electrical-analog model of ear-canal acoustics and middle-ear mechanics produced good fits to the measured absorbance for ears with OME as well as age-matched control ears. Both initial model-based CHL estimates were well correlated with PTA. However, the CHL estimates based on damping revealed an unexpected feature. In roughly a third of the ears

(11/34), these estimates were too large by a factor of two. Adjusted estimates that accounted for this observation improved the PTA correlation to 95% and achieved a prediction error of 3.2 dB (mean absolute difference).

Conclusions: Overall, these results suggest that WAI absorbance, combined with a computational model, can estimate behavioral audiometric thresholds within a clinically meaningful margin of error. This is a significant finding given the challenges associated with behavioral audiometric testing in pediatric populations where OME is most common.

Category: Diagnostic Audiology / Otology

Poster #: 093

Comparison of Two Distortion Product Otoacoustic Emission (DPOAE) Growth Measurement Paradigms

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Objectives: Distortion product otoacoustic emission (DPOAE) growth functions assess the growth of cochlear distortion - due to nonlinear mechanical overlap of stimulus tones - as a function of stimulus level. DPOAE growth functions have been used to non-invasively evaluate various cochlear phenomena, including to characterize cochlear aging. However, the extent to which the stimulus level paradigm used to measure DPOAE growth can affect the shape and morphology of the resulting growth function is unknown. The objective of this study is to compare two approaches used to measure DPOAE growth functions: the "scissors" method (stimulus levels co-vary) and the "fixed L1" method (one stimulus level remains fixed while the other is varied).

Design: DPOAE growth functions will be measured from .5-20 kHz in 10 ears using two distinct stimulus level paradigms: the "scissors" method and the "fixed L1" method. The scissors method will use L1 and L2 probe tones that co-vary in level ($L1 = 0.4 * L2 + 39$ dB SPL) from 0-70 dB FPL. The fixed L1 method will use an L1 probe tone that is fixed in level at 70 dB FPL, and an L2 probe tone that varies in level from 0-70 dB FPL. Participants will have behavioral thresholds within normal limits based on normative data from our lab.

Results: Data collection and analysis is ongoing. We will report individual and group differences in DPOAE growth functions assessed using the two measurement paradigms. We will compare the shape, slope, and morphology of growth functions measured using both paradigms. We will also discuss analysis methods of DPOAE growth functions and the connection between growth function shape and underlying cochlear physiology.

Conclusions: DPOAE growth functions have the potential to become a powerful clinical tool, particularly for understanding and assessing age-related declines in hearing. Before using DPOAE growth as a clinical tool becomes a reality, we must understand how it is impacted by the measurement paradigm.

Category: Diagnostic Audiology / Otology

Poster #: 094

Middle Ear Function in Aminoglycoside-Exposed Adults with Cystic Fibrosis

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Objectives: Cystic Fibrosis (CF) is an autosomal recessive genetic disorder, caused by mutations in the cystic fibrosis transmembrane conductance regulator gene (CFTR). Individuals with CF typically experience mucous build-up in the lungs, increasing their risk of life-threatening infections. These are commonly treated with intravenous aminoglycoside (IV-AG) antibiotics like tobramycin and amikacin, which have known ototoxic effects. However, the middle ear mechanics of individuals with CF are poorly understood. The CFTR protein is expressed in human middle ear epithelial cells, but it is unclear whether middle ear disease is more prevalent in individuals with CF. Previous studies have demonstrated that wideband absorbance is more sensitive to middle ear dysfunction than traditional clinical metrics, including static acoustic admittance at 0.226 kHz and air-bone gaps. The aim of this study was to compare middle ear function in adults with normal hearing who had CF with an age- and gender-matched control group. It was hypothesized that based on wideband tympanometry, subjects with CF would demonstrate reduced low-frequency absorbance at tympanometric peak pressure, broader tympanometric width and reduced peak-to-tail differences compared to non-CF controls due to increased middle ear stiffness.

Design: The hearing and middle ear function was evaluated in 57 adult subjects with CF and 29 age- and gender-matched control subjects. Participants with CF were stratified by lifetime IV-AG exposure based on chart review. Fifteen participants with CF had no IV-AG exposure, 21 participants received 40 doses or fewer, and 21 participants received over 40 doses. Procedures included pure-tone air conduction and bone conduction audiometry, 0.226 kHz static acoustic admittance and wideband down-swept tympanometry from 0.250 to 8 kHz using an experimental wideband research system. The following tests were compared between groups based on wideband tympanograms: tympanometric width of the averaged low-pass filtered absorbance tympanogram, absorbance peak-to-tail differences at \pm octave frequencies, and tympanometric width of equivalent admittance tympanograms measured at the tympanic membrane at octave frequencies.

Results: There were no significant differences between groups for 226 Hz static acoustic admittance, absorbance at tympanometric peak pressure, or audiometric air-bone gaps. However, individuals with CF demonstrated wider low-pass filtered absorbance tympanograms from 0.376 kHz to 2 kHz and wider equivalent admittance tympanograms from 0.250 kHz to 1 kHz compared to controls. Across IV-AG exposure groups, individuals with the greatest exposures demonstrated wider equivalent admittance tympanograms and reduced peak-to-tail differences for both the negative- and positive-pressure tails, primarily below 2 kHz, as compared to CF participants with no IV-AG exposure.

Conclusions: Participants with CF demonstrated greater wideband tympanometric width in the low frequencies for both absorbance tympanograms and tympanograms of equivalent admittance at the TM compared to controls. This is suggestive of greater middle-ear stiffness in patients with CF that increased with greater IV antibiotic use in the presence of normal puretone audiometric thresholds. Wideband middle ear measurements were more sensitive at detecting the difference in middle ear mechanics than traditional 0.226 kHz static acoustic admittance or audiometric air-bone gaps. These results support the use of wideband tympanometry as a sensitive measure for the assessment of middle ear function in patients with CF.

ELECTROPHYSIOLOGIC RESPONSES

Category: Electrophysiologic Responses

Poster #: 095

Effects of Babble Noise on Middle Ear and Olivocochlear Reflexes

Poster Withdrawn

Category: Electrophysiologic Responses

Poster #: 096

Pitch Discrimination and the Acoustic Change Complex in Children and Adults

Poster Withdrawn

Category: Electrophysiologic Responses

Poster #: 097

Amplitude-Modulated-cVEMP: A Novel Method to Assess Saccular Functioning in Aging

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Objectives: Limitation in the assessment of the vestibular system leaves 20-30% of patients with vestibular complaints undiagnosed. There is a need to develop techniques to study vestibular mechanisms that cannot be tapped using existing methods. The present study uses an innovative approach including amplitude-modulated tones to elicit a cVEMP (AMcVEMP). AMcVEMP provides information about the sustained activity of saccular stimulation that cannot be obtained using conventional transient cVEMP. Moreover, AMcVEMP has been the only technique to indicate non-linearity in the human vestibular system, an aspect of saccular physiology that has not been studied in aging. The purposes of the present study are to 1. Characterize the effects of age on the AMcVEMP, 2. Examine the effects of carrier frequencies (250 and 500 Hz) on the AMcVEMP across different age groups, and 3. Determine evidence of vestibular non-linearity in young, middle age and older adults. The hypotheses of the present study are that 1. AMcVEMP amplitude, SNR, phase coherence, and magnitude squared coherence will become poorer with increasing age, 2. 250 Hz would be a better carrier frequency to elicit AMcVEMP compared to 500 Hz, and 3. We will see more evidence of non-linearity in young adults compared to older groups.

Design: Young (n = 30), middle-aged (n = 22), and older (n = 16) adults with no history of vestibular lesions or middle-ear pathologies were included. Stimuli used were carrier frequencies (CF): 250 Hz and 500 Hz tones,

amplitude modulated using 37 Hz. Stimuli were presented from 65 to 40 dB HL for 500 Hz CF and from 35 to 20 dB HL for 250 Hz using a B81 bone oscillator. AMcVEMP analyses were FFT based looking for responses at the modulation frequency (37 Hz). For non-linearity measures, responses were looked at the harmonics of the modulation frequency.

Results: As an effect of aging, significant degradation in the amplitude, SNR, phase coherence, and magnitude squared coherence measures were seen. These age differences were seen at all the stimulus levels at both the carrier frequencies. The threshold was best (lowest) for younger adults (500 Hz, mean = 52.9; 250 Hz, mean = 28.33) followed by middle age (500 Hz, mean = 61.18; 250 Hz, mean = 31.36) and poorest for the older adults (500 Hz, mean = 65.32; 250 Hz, mean = 33.67). A higher percentage of responses were present at 250 Hz compared to 500 Hz; fewer responses were present as age increased. Responses were also present at the harmonics of modulation frequency in most young, some middle-aged adults and none of the older adults.

Conclusions: Results show a significant age-related decline in the measures of AMcVEMP. Further, these findings are consistent with a loss of vestibular non-linearity as an effect of aging. Compared to 500 Hz, it would be a better to use a CF of 250 Hz to elicit AMcVEMP because of higher response rates probably due to its proximity to saccular resonance. Implications for clinical practice and vestibular diagnostics will be discussed.

Category: Electrophysiologic Responses

Poster #: 098

Predicting 6- and 8-kHz Thresholds in Children using Tone-Burst ABR

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Objectives: Clinical auditory brainstem response (ABR) testing is the recommended method for estimating hearing sensitivity in those for whom reliable behavioral responses to sound cannot be obtained. Currently, clinical ABR testing is typically limited to frequencies ≤ 4 kHz. This is a significant problem as around 75% of infants are diagnosed with hearing loss by 3 months of age based on ABR results, well before an age at which behavioral testing of hearing sensitivity is developmentally possible. There is converging evidence that high frequency information is important for speech understanding, localization, and listening in adverse acoustic environments. As a result, there is growing clinical interest in performing ABR testing at high frequencies to inform early intervention efforts and promote optimal outcomes for infants and young children with hearing loss. However, the ability of ABR assessment to predict behavioral sensitivity above 4 kHz in pediatric populations is currently unknown. Therefore, the objective of this project is to test the hypothesis that ABR thresholds predict behavioral hearing thresholds for 6 and 8 kHz tone-burst stimuli in children with hearing loss and children with normal hearing.

Design: A total of 39 children ranging in age from 4.7 to 16.7 years (mean = 10.4, stdev = 3.5) were included in the study (n = 45 ears with hearing loss; n = 41 ears with normal hearing). Participants were recruited using the Boys Town National Research Hospital research database and medical records system. Participants had either normal hearing sensitivity or sensorineural hearing loss at octave frequencies 0.25-8 kHz and 6 kHz, normal

middle ear function, and no history of epilepsy or seizures. A modified Hughson-Westlake procedure was used to obtain behavioral thresholds. Presentation level for ABR testing started at 40 dB SL or the limits of the test equipment; threshold was defined as the lowest level at which wave V was identified and replicated.

Results: Absolute differences between ABR and behavioral threshold ranged between 0 and 20 dB for both 6 and 8 kHz (6 kHz, mean = 5.4, stdev = 5.0; 8 kHz, mean = 6.3, stdev = 5.5). Linear mixed-effects modeling showed a significant main effect of ABR threshold on behavioral threshold ($p < 0.001$). An ABR by frequency interaction was not observed ($p = 0.952$).

Conclusions: The results suggest ABR testing can be used to estimate behavioral hearing sensitivity at 6 and 8 kHz in children with hearing loss and children with normal hearing. Average differences in threshold estimates between test types was approximately 5 dB. The accuracy of using ABR testing at 6 and 8 kHz ABR to predict behavioral threshold did not differ between frequencies. In accordance with prior studies that assessed tone-burst ABR thresholds at or below 4-kHz and behavioral thresholds of hearing sensitivity, the current study found a strong correlation between ABR thresholds and behavioral threshold. The findings of this study are directly applicable to clinical decision-making, including diagnosis and monitoring of high-frequency hearing loss and hearing aid fittings for pediatric populations.

Category: Electrophysiologic Responses

Poster #: 099

Comparison of Cortical Auditory Evoked Potentials Across Data Acquisition Systems

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Objectives: Cortical auditory evoked potential responses (CAEPs) inform how stimuli are processed on the cortical level, providing insight into sensory as well as higher-order cognitive processes. The present study sought to compare CAEPs measured using the same experimental paradigm (auditory incidental memory) and stimuli with a 128-electrode research system (Electrical Geodesics, Inc.) and a prototype clinical system using a 4-electrode montage (Intelligent Hearing Systems). We hypothesized that similar CAEP patterns indexing auditory memory response would be observed for both systems.

Design: Thirteen normal hearing adults (9 female, 4 male) with a mean age of 27 years participated in this study. Baseline testing confirmed normal hearing sensitivity. CAEP testing was completed in two sessions between 2 and 7 days apart. One session used a clinical system for collecting CAEPs, and the other session used a research system. The order of the test sessions was counterbalanced across the participants. Stimuli included 51 single-syllable pseudowords, of which one was chosen at random to be repeated 50 times and the rest were presented once, for a total of 100 randomized trials. Participants were instructed to watch a silent video, and no active stimulus repetition detection was required. Data were analyzed to extract windowed amplitudes in response to repeated or novel stimuli. CAEPs for the research system were extracted manually, while an automated data processing algorithm was implemented for the clinical system.

Results: The expected sensory CAEP responses (P1-N1-P2) and the auditory memory response (400-600ms) were observed at the Cz electrode cluster for the research system. Similar findings were noted using the clinical system, with the greatest separation between waveforms for the repeated vs. novel stimuli conditions also

observed in the 400-600 ms time window at Cz. Statistical analyses using the clinical system data were consistent with the research system data.

Conclusions: Results indicated that the same experimental paradigm (auditory incidental memory) and stimuli (pseudowords) can be implemented using research and clinical systems with different numbers of electrode channels. The CAEPs demonstrated comparable morphologies across the two equipment types, supporting the hypothesis that research paradigms can be successfully translated for use on a clinical system. Practical implications include the potential for expanded evaluations beyond sensory processing, especially in nonverbal or medically complex patient populations, where CAEPs could provide additional useful information on higher-order auditory processing. [Supported by NIH-NIDCD T35-DC008763]

Category: Electrophysiologic Responses

Poster #: 100

Maximizing the Late Latency Auditory Steady-State Response

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Objectives: The use of a low modulation frequency steady-state response, termed the Late Latency Auditory Steady-State Response (LLASSR), incorporating stimulus presentation jitter, is explored as a clinical tool. Auditory Evoked Potentials (AEPs) provide objective physiologic measures that have clinical applications in assessing neural synchrony and estimating hearing sensitivity. Steady state responses provide an advantage over transient AEPs because responses can be analyzed objectively using spectral techniques. Additionally, slower stimulus rates facilitate recording of responses from the auditory cortex, permitting comprehensive examination of the auditory pathway. Combining the benefits of both low modulation rate and a steady-state paradigm has broad research and clinical implications, including testing of patients lacking neural synchrony at the brainstem level, such as those with auditory neuropathy. While slower stimulus rates and higher intensities typically lead to higher amplitude responses, faster presentation rates may facilitate clinical use. We hypothesized that use of a jitter paradigm could compensate for the adverse effects of faster stimulus rate and lower intensity by reducing habituation and the subsequent effect on response amplitude.

Design: Participants were fifteen adults with normal hearing. The variables of stimulus rate, stimulus intensity, and the presence of jitter in the presentation sequence were examined. Brief tones centered at 1000 Hz were presented in trains of 40 stimuli. Stimulus rates were 0.781 Hz and 1.562 Hz. Stimuli were presented at 80 dB SPL and at 40 dB SPL, a level closer to threshold. The concept of jitter was introduced by randomly varying the time between stimuli to change the expectation level. Eight test conditions were completed for each subject with variations in stimulus rate, stimulus intensity, and presence of jitter. A linear mixed effects model assessed the effects of intensity, rate, and condition (jitter versus traditional). Results also were analyzed with inclusion of harmonic data.

Results: Significant response amplitude findings included increased amplitude in the presence of jitter, increased amplitude with a slower stimulus rate, and decreased amplitude in the lower intensity condition. An intensity and rate interaction was observed, where P1-N1 peak-to-peak amplitude decreased in the low intensity

condition only when a slow rate was used. Intensity was the only variable with a significant effect on latency, with lower intensity increasing P1 latency.

Conclusions: The new, important finding in this study is that the addition of jitter consistently provided a response amplitude advantage over traditional paradigms. While further study is needed with a larger number and various types of participants, these results suggest potential benefit of adding jitter to paradigms, particularly where a faster presentation rate or lower intensity is used. This serves to broaden clinical and research applications of LLASSR because deviation from the optimal stimulus rate may not require sacrifice of amplitude. [Supported by NIH-NIDCD T35-DC008763]

Category: Electrophysiologic Responses

Poster #: 101

Effect of Real-Ear Adjusted Stimuli on VEMP Variability

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Objectives: There is large variability in vestibular evoked myogenic potential (VEMP) amplitudes. One potential source of variability is differences in ear canal shape and size. Real-ear-to-coupler difference (RECD) values measure the acoustic environment of an individual's ear canal. RECD may be a useful measure to calibrate air conducted VEMP stimuli, which are elicited at high intensities and may put patients at risk of unsafe sound exposure. A recommendation for avoiding unsafe exposure is to use a 125 dB SPL stimulus for individuals with an equivalent ear canal volume (ECV) ≥ 0.9 mL and a 120 dB SPL stimulus for individuals with a smaller ECV. The purpose of this project was to determine if using a stimulus calibrated in the ear using RECD values significantly reduces intra-subject and inter-subject VEMP amplitude variability. We hypothesized that using a RECD-calibrated stimulus would reduce variability and better protect against delivering unsafe sound exposure compared to the method of using ECV alone.

Design: 11 children (4-9 years), 10 adolescents (10-18 years), and 10 young adults (20-40 years) with normal hearing, tympanometry, vestibular and neurological function participated. All subjects completed RECD twice per ear to account for test-retest reliability. Cervical and ocular VEMPs were then recorded bilaterally with a 500 Hz toneburst at a traditional and an adjusted VEMP intensity level. The traditional intensity level was 125 dB SPL for individuals with ≥ 0.9 mL ECV and 120 dB SPL for individuals with ≤ 0.8 mL ECV. The adjusted intensity level was calculated by subtracting the average 500 Hz RECD measured values from the 500 Hz normative RECD value. This value was applied as a correction factor to a 125 dB SPL stimulus. Peak-to-peak amplitudes were recorded and used to calculate asymmetry ratios.

Results: Young children had significantly smaller ECVs compared to adolescents and young adults. Young children also had larger RECDs; however, this was not significant in post hoc analyses. The method of calibration had no significant effect on intra-subject variability for cervical ($F(1, 27) = .996, p = .327$) or ocular VEMPs ($F(1, 25) = 1.679, p = .206$). The method of calibration also had no significant effect on inter-subject amplitude variability for cervical ($F(1, 120) = .721, p = .397$) or ocular VEMPs ($F(1, 120) = .447, p = .505$). Each method of calibration adequately protected against unsafe exposure levels; however, using the ECV-calibrated

method, there were subjects with large ECVs approaching unsafe exposure levels, suggesting there may be rare cases in which a patient with a larger ECV receives unsafe levels of stimulation.

Conclusions: The calibration method made no significant difference in intra- or inter-subject variability, indicating that the acoustic environment of the outer ear is not significantly contributing to VEMP amplitude variability. The RECD-adjusted stimulus is effective in protecting against unsafe exposure levels for 2 trials of both c- and oVEMPs. There may be instances where more than 2 trials of each test are required, which increases the effective stimulation level. Clinicians should be cautious when delivering VEMPs and not unnecessarily expose patients to unsafe levels of sound.

Category: Electrophysiologic Responses

Poster #: 102

Using Long-Duration Noise Bursts for Measurements of Central Auditory Gain

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Objectives: In this companion study to earlier work published by Gonzalez and Musiek (2021), the onset-offset N1-P2 auditory evoked response was measured using 500 Hz and 4000 Hz narrowband noise (NBN) presented to two groups of participants: 1) those with normal pure-tone hearing sensitivity (NH) and 2) those with normal low-frequency hearing sensitivity sloping to moderate high-frequency sensorineural hearing loss (HFSNHL) from 2000 through 8000 Hz. Main goals were to determine whether there were differences in direct amplitude and/or latency measurements between groups for 500 Hz NBN stimuli (hypothesis: no) and 4000 Hz NBN stimuli (hypothesis: yes) and whether there were differences in indirect offset-to-onset trough-to-peak N1-P2 amplitude ratio (OOAR) measurements (calculated by dividing trough-to-peak N1-P2 offset amplitude by trough-to-peak N1-P2 onset amplitude for each participant) between groups (hypothesis for 500 Hz: no; hypothesis for 4000 Hz: yes) and stimuli (hypothesis for NH: no; hypothesis for HFSNHL: yes).

Design: Waveforms were obtained from 10 participants with normal hearing and seven participants with moderate HFSNHL aged 40-67 years. Stimuli of 2000 msec duration with 40 msec rise/fall times were constructed using equivalent rectangular bandwidths (ERB) for 500 Hz and 4000 Hz center frequencies and presented to each participant at 50 dB SL re: behavioral threshold for the test stimuli. Amplitudes and latencies were analyzed using repeated measures ANOVA for N1 and P2 onset and offset components, and OOARs were compared between groups using one-way ANOVA and across stimuli using paired samples t-tests. Bonferroni corrections were used to adjust for multiple comparisons.

Results: Despite differences in dB SPL stimulus presentations between groups, there were no significant differences between groups for any direct onset or offset amplitude or latency measurements for either stimulus. OOARs for 4000 Hz NBN were significantly larger for the HFSNHL group than the NH group; OOARs for 500 Hz NBN did not reach significance between groups. OOARs between stimuli for the NH group were identical (.38 for both 500 Hz and 4000 Hz NBN) but reached significance for the HFSNHL group (4000 Hz NBN OOAR = .62; 500 Hz NBN OOAR = .32).

Conclusions: It is speculated that similarities between groups for the direct amplitude and latency measurements indicate that a homeostatic central auditory gain mechanism has succeeded in achieving relatively equal excitation in the auditory cortices of subjects with HFSNHL, but that differences in the indirect, derived

calculation of OOAR demonstrate the relative reductions in inhibition that have taken place to achieve that excitability. This disruption in excitatory-inhibitory balance may be what is observed in the 4000 Hz NBN OOAR data; this calculated measure may be an electrophysiologic biomarker for a homeostatic central auditory gain mechanism that is acting in response to reductions in peripheral input. With further research and development, OOAR measurements may become a useful tool in measuring the relative excitatory-inhibitory balance changes in the CANS resulting from auditory pathology. OOAR measurements may also be useful as an objective measurement of responses to intervention for auditory pathology, including auditory training and acclimatization to amplification.

HEARING LOSS / REHABILITATION

Category: Hearing Loss / Rehabilitation

Poster #: 103

Association between Dual Sensory Loss and Depressive Symptoms in India

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Objectives: Prior work suggests that vision and hearing loss may be risk factors for depressive symptoms in older adults. However, few studies have focused on the relationship of both vision and hearing loss (dual sensory loss) and depressive symptoms. Additionally, most research on depressive symptoms is focused on high income countries. According to the World Health Organization, almost 80% of people with moderate or higher levels of hearing loss live in low-income and middle-income countries. Also, the prevalence of distance vision loss in low-income and middle-income regions is about four times greater than high-income regions. To address these research gaps, we investigated the association between dual sensory loss and depressive symptoms among the older Indian population.

Design: We use data from the 2017 and 2019 Wave 1 of the population-based Longitudinal Aging Study in India (LASI), the first nationally representative population survey of health, economic, and social factors of aging on a large national sample in India. The sample was drawn from individuals aged 45 years and older and their spouses in 35 states and union territories of India. Our study sample consists of 65,333 respondents aged 45 years and older with complete exposure, outcome, and covariate data (90.4% of the original sample, 53% men, mean±SD age 59.0±10.3 years). The Centre for Epidemiologic Studies Depression (CES- D) scale was used to determine the presence of clinically significant depressive symptoms (≥4 points). The Composite International Diagnostic Interview (CIDI-SF) scale was used to identify major episodic depression (≥3 points). Dual sensory loss was determined by respondents' self-reported, perceived difficulty regarding hearing (hearing aid use, prior diagnosis of hearing/ear-related problems) and vision (poor/very poor report of distance or near vision) function. Sensory loss was modeled as no loss (reference), vision loss only, hearing loss only, and dual sensory loss. Multivariable-adjusted logistic regression was used to estimate the odds ratios (OR) and 95% confidence intervals (CI) between sensory loss and depressive symptoms.

Results: Overall, 20.1% had vision impairment, 4.49% had hearing impairment, and 2.3% had both. After adjusting for age, sex, education, caste, marital status, urbanicity, region, diabetes, heart disease, hypertension, stroke, and smoking history, visual and hearing loss (vs. no loss) were associated with an increase in depressive symptoms (OR, 1.44; 95% CI, 1.37 to 1.50 and OR, 1.22; 95% CI, 1.11 to 1.33, respectively). Dual sensory loss (vs. no loss) was associated with 78% higher odds (95% CI, 1.58 to 1.98) of depressive symptoms. Similar associations were observed for CIDI-SF major episodic depression; the strongest association was found for dual sensory impairment (OR, 2.20; 95% CI, 1.84 to 2.56).

Conclusions: Poor vision and/or hearing loss may be a risk factor for depressive symptoms in adults in India aged ≥ 45 years. The association was strongest for those with both vision and hearing loss, suggesting that adults with sensory loss across multiple systems may be an especially important group to target for intervention. Whether treatment or rehabilitation can ameliorate depressive symptoms in those with sensory loss should be investigated in further studies.

Category: Hearing Loss / Rehabilitation

Poster #: 104

Caregiving Effects on Caregivers Assisting Older Adults with Hearing Loss

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Objectives: Hearing loss may strain communication between caregivers and recipients which could result in poorer caregiving outcomes (unhealthy relationship, greater burden, chronic stress, etc.). This research aims to characterize the extent to which hearing loss affects caregivers' burden and feelings of job burnout, and explore potential protective factors (e.g., hearing aid ownership). We hypothesize that caregivers of older adults with hearing loss are more likely to experience negative caregiving circumstances and have an increased risk of job burnout.

Design: Study Design: Cross-sectional analysis. Setting and Participants: The National Health and Aging Trends Study (NHATS) and National Study of Caregiving (NSOC) provide a nationally representative sample of family and unpaid caregivers of community-dwelling older adults with disabilities. This analysis includes a pooled sample from 2011, 2015, and 2017 rounds of NHATS and NSOC data, with information collected on 3,153 older adults and their 6,863 family caregivers. Exposure: self-reported hearing loss as a composite exposure among care recipients. Outcomes: Caregiving effects as the primary outcome (perceived difficulties in physical, emotional, and financial domains). Caregivers' feeling of burnout (exhaustion and low personal achievement [LPA]) as the secondary outcome. Analysis: Multiple linear regression models with propensity score matching on demographic, socioeconomic, and health characteristics were adopted to characterize the association between hearing loss and caregiving outcomes. A secondary analysis was conducted in the sub-population of exposed participants to evaluate the effect of hearing aid ownership on the major outcomes.

Results: The crude prevalence of hearing loss among caregivers and recipients in 2017 are 9.3% (95% CI=7.5%-11.5%) and 34.2% (95% CI=30.3%-38.3%), respectively. Based on the fully adjusted model, the presence of care recipients' hearing loss is associated with a 17.4 hour (95% CI: 6.0-28.7) increase in caregivers' monthly caregiving time, elevated risk of perceived emotional difficulties (Odds Ratio [OR]=1.2; 95% CI=1.0-1.6) and feelings of job burnout (exhaustion: OR=0.85; 95% CI=0.63-1.10). In the secondary analysis, hearing aid owners are less likely to report emotional difficulty (OR=0.56; 95% CI=0.11-1.01) and have lower levels of

financial insecurity (OR=0.33; 95% CI=0.09-1.15), as compared to their counterparts. Dementia status and the relationships between caregivers and care recipients (being a spousal caregiver vs. not) were identified as potential modifiers of the aforementioned associations.

Conclusions: Given the rapid shift in demographic characteristics of caregiving dyads and the steady increase in the prevalence of age-related hearing loss among the care recipient population. This study highlights the difficulties faced by family caregivers assisting older adults with hearing loss. It also demonstrates the needs of those caregivers and possible sources of disparities caused by the presence of comorbidities, lack of access to hearing devices, and other external supports.

Category: Hearing Loss / Rehabilitation

Poster #: 105

Roadmap to Comprehensive Ototoxicity Management for Cancer Treatment

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Objectives: The International Ototoxicity Management Working Group (IOMG) focus area on Ototoxicity of Cancer Treatment launched regular meetings in June 2021. Ototoxicity management in this context includes the diagnosis, monitoring, rehabilitation and therapeutic treatment of individuals who experience hearing loss, tinnitus, or balance/vestibular difficulties following cancer treatment exposures. Despite the well-established physical, socio-economic, and psychological consequences of hearing and balance dysfunction, clinical practice in management of patients receiving ototoxic treatments is not consistent within or across countries. Few healthcare delivery models integrate ototoxicity management into the essential and often life-preserving care pathways that utilize therapies that unavoidably increase the risk of ototoxicity. The primary objective is to 1) convey the outcomes of our initial survey and 2) propose a roadmap for ototoxicity management in the realm of cancer treatments.

Design: The members (n=43) comprising subject matter experts (representing audiologists, nurses, physicians, students, researchers, and patient perspectives) in this area were surveyed regarding ototoxicity management specific to what they perceived as the highest and lowest priority items for this focus area to address. The survey priorities were collapsed into overarching topic areas and used as the foundation of the first meeting brainstorming session. The survey and subsequent discussion confirmed the need to develop a call to action or roadmap, to guide and prioritize the focus group's activities.

Results: Twenty-three survey responses were obtained from this initial survey organized by the co-chairs into (7) topic areas with combined overlapping items. A subgroup of volunteers was identified to begin development of the roadmap framework and scope. In addition to the identified priority topics, the subgroup proposed a structured approach for the roadmap patterned after the Schmitz et al. (2020) example that demonstrates how a gap between comprehensive patient management programs and appropriate referral can be closed with a multi-step approach. Specific recommendations are offered in five key areas: 1) workforce enhancement, 2) program development, 3) research and evaluation, 4) stakeholder awareness, empowerment, and engagement, 5) policy, funding, and sustainability.

Conclusions: Outcomes support development of consensus recommendations and a roadmap to ototoxicity management of cancer treatment. These recommendations can be used to guide development of effective ototoxicity management programs, direct research efforts, address the needs of caregivers and patients across the continuum of care.

Category: Hearing Loss / Rehabilitation

Poster #: 106

Accompaniment Reduces Healthcare Dissatisfaction Among Medicare Beneficiaries with Hearing Loss

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Objectives: Previous work suggests hearing loss is associated with decreased satisfaction with quality of health care, potentially mediated by communication barriers. It is plausible the association is modified by the presence of another person (family, friend, caregiver, etc.) who could act as a communication buffer during health care interactions. We aim to characterize whether the association between hearing trouble and satisfaction with care is modified by the presence of a companion to health care visits.

Design: This cross-sectional analysis used the 2016 Medicare Current Beneficiary Survey file, an annual nationally representative health care survey of Medicare beneficiaries. The analytic sample included 10,422 Medicare beneficiaries 65 years (representing 44.4 Million with survey weighting) and older who reported an interaction with the health care system in the last year. The primary outcome was satisfaction with care, which was measured in three ways: (1) satisfaction with quality of care, (2) satisfaction with information provided, and (3) satisfaction with provider's concern. The primary exposure was self-report trouble hearing while the modifier of interest was self-report accompaniment to health care visits by someone who saw the doctor with the participant (i.e., did not sit in the waiting room). Multivariable ordinal logistic regression was used to model the association between hearing trouble and the satisfaction variables after adjusting for sociodemographic and health covariates. Models were then stratified by accompaniment status to characterize modification.

Results: In the full weighted sample, 55.2% reported no trouble hearing while 39.2% and 5.7% reported a little and a lot of trouble hearing, respectively. Compared to participants with no trouble hearing, those with a little (Odds Ratio [OR] = 1.168; 95% Confidence Interval [CI] = 1.047-1.302) and a lot of trouble (OR = 1.293; 95% CI = 1.043-1.603) hearing had higher odds of reporting being very dissatisfied with the overall quality of care over the past year. In stratified models, among those who were accompanied (n=3,436), trouble hearing was no longer associated with dissatisfaction with care (A lot of trouble hearing: OR = 1.115; 95% CI = 0.831-1.498) while among those who were unaccompanied (n=6,262), the magnitude of effect size was larger than in the main model such that those with a lot of trouble hearing had a 1.5-fold increase in odds (OR = 1.524; 95% CI = 1.126-2.065) of being dissatisfied relative to those without trouble hearing. The direction of stratified results was consistent across other satisfaction variables. Notably, among included covariates in the models, hearing trouble is the only variable consistently modified in such a manner.

Conclusions: In a nationally representative survey of Medicare beneficiaries, those with trouble hearing had higher odds of dissatisfaction with care compared to those with no trouble hearing. However, in a first-in-kind

analysis, it appears that accompaniment to health care visits modifies this association. These findings further support calls for accommodations for hearing loss in health care settings to address health disparities. The findings are limited by the cross-sectional nature of the work, self-report hearing, and potential unmeasured confounding.

Category: Hearing Loss / Rehabilitation

Poster #: 107

Values in Hearing Healthcare Service Delivery

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Objectives: Untreated hearing loss is a significant public health issue which negatively affects cognition, independence, social/emotional health, and overall quality of life for millions of Americans. Barriers to treatment invite novel and innovative solutions. Values-sensitive design is an approach that can be used to develop solutions that preserve the values important to the stakeholders involved. The goal of the current study was to characterize the intended and enacted values in hearing healthcare service delivery.

Design: A three-step qualitative content analysis approach was used to create a comprehensive list of values in hearing healthcare. In step 1, team members identified textual documents that represent the intended and enacted values in hearing healthcare. In step 2, a preliminary codebook was created through a top-down approach in which team members with expertise in values research and audiology created a list of potential values in hearing healthcare. In step 3, an iterative, bottom-up approach was used to refine the preliminary codebook as it was applied to relevant documents.

Results: The result of this study is a comprehensive list of values in hearing healthcare service delivery. Values were organized into three main categories: instrumental, patient use, and moral.

Conclusions: We applied a theoretical framework from values research to systematically assess hearing healthcare service delivery. Future applications of this list could include comparisons of the values of different stakeholders including but not limited to individuals with hearing loss, health care providers, hearing aid manufacturers, and legislative bodies that regulate the marketing and sale of hearing aids.

Category: Hearing Loss / Rehabilitation

Poster #: 108

Partnership-Centered Audiology Service Model for Older Adults with Hearing Loss

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Objectives: In the current climate, audiologists must reconsider the role and value of service provision. Family-centered service frameworks are employed when working with children; for adult services, however, audiologists focus on person-centered goals. We typically use limited clinical resources to focus on devices, audibility, and measurement of speech recognition. Here we describe a different framework for remediation of hearing loss in adults: relationship-centered services. The current project aims to develop methods to measure effects of hearing loss on the client and a close partner. Hearing loss in older adults is often noticed first by close partners, and the hearing loss affects those partners as well. We evaluated perceived disability through questionnaires and rating scales.

Design: Clients with hearing loss (ages 60 to 80 years) and their close partners completed intake forms concerning the impact of the client's hearing loss. Surveys included the Significant-Other Scale (SOS-HEAR), International Outcomes Inventories, Speech-Spatial-Quality-12, HHIE and Social Participation (SPARQ). Questions were also posed to the client and partner following guidelines from COSI. Interim data from 13 partnerships will be presented here.

Results: Questionnaire responses revealed complex mismatches between clients' and partners' perceptions. SSQ and SPARQ results revealed unpredictable patterns within pairs, with differences observed on either both, one, or none of the questionnaires administered. When the client and partner had similar scores on the SPARQ, they showed similar scores on the SSQ. However, the opposite was not true. When the client and partner differed, patterns of mismatch emerged: (1) client scores revealed greater impact of hearing loss than acknowledged by the partner; (2) partner scores revealed greater impact of hearing loss than indicated by the client; or (3) a mix of both. Overall COSI results were highly variable across partnerships. Some partners showed a mismatch between how they view hearing loss for the client compared to how the client's hearing loss affects their own life. COSI scales revealed issues related to third-party disability, such as the partner having apprehension toward communication with their partner with HL, lamenting the loss of social engagement, and the feeling of responsibility to assist their partner with HL. Importantly, these often-overlooked issues were only apparent partners were directly asked about their own experiences. They would not come to light during standard audiologic appointments, focused on the individual.

Conclusions: Our findings show that each individual and relationship is different, requiring tailoring of the rehabilitation process to better fit the individual client/partner needs. No single questionnaire captured the full pattern of responses from client and partner. We aim to design a protocol for creating a custom set of partnership-based goals where we consider both client and partner's viewpoint on situations that are important, difficult, and frequently occurring, and in particular identifying those situations that cause high frustration levels for both people. It is our long-term goal to improve the shared understanding of the effects of hearing loss on relationships and to focus audiology services on those needs unique to each partnership that are most likely to have a positive impact on daily living.

Category: Hearing Loss / Rehabilitation

Poster #: 109

Satisfaction with Care, Hearing Loss, Hearing Aids, and Race

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Objectives: Both hearing and race have been associated with reduced satisfaction with healthcare; however, there are no known studies that have examined the intersection of hearing loss and race in this body of research. It is plausible that communication barriers from hearing loss may be exacerbated by structural racial inequities of the health care system. The purpose of this study is to investigate the interaction of hearing loss and race/ethnicity on satisfaction with care and to determine whether hearing aid use modifies the association across individuals of different races/ethnicities.

Design: We combined the 2013-2018 cycles of the National Health Interview Survey, an annual national survey of the civilian noninstitutionalized population of the U.S. Participants who completed modules on health care utilization and hearing loss were included. The primary outcome was "satisfaction with quality of medical care over the past year" and was recoded as a binary with an outcome of optimally satisfied (an answer of "very satisfied") or less-than-optimally satisfied (answers of "somewhat satisfied," "somewhat dissatisfied," or "very dissatisfied") which is consistent with satisfaction with care literature due to statistical distribution of the result. Hearing was self-report without a hearing aid (good/excellent hearing, little trouble hearing, and moderate/a lot of trouble hearing). Participants could identify as Black, non-Hispanic, Hispanic, or white, non-Hispanic. Other covariates include education, income to poverty ratio, insurance type, marital status, and usual source of care other than emergency room. We derived prevalence ratios using poisson regression with robust error variance in models stratified by race/ethnicity to explore modification of associations between hearing and satisfaction with care by race/ethnicity.

Results: The final analytic sample include 128,263 participants. In the general population, hearing loss was associated with less-than-optimal satisfaction with quality of healthcare. In models stratified by race, associations between hearing loss and less-than-optimal satisfaction remained for all strata suggesting no presence of modification by race/ethnicity. Compared to those with excellent/good hearing, those with moderate/a lot of trouble hearing had higher prevalence of reporting less than optimal satisfaction with care among the Black, non-Hispanic group (PR: 1.21; 95% Confidence Interval [CI], 1.10-1.33), followed by the white, non-Hispanic group (PR: 1.15; 95% CI, 1.10-1.19) and the Hispanic group (PR: 1.14; 95% CI, 1.03-1.25). Among those with hearing loss, hearing aid use was protective against less-than-optimal satisfaction with care among, both white, non-Hispanic (PR: 0.82; 95% CI, 0.76-0.87) and Black, non-Hispanic (PR: 0.72; 95% CI, 0.57-0.92). However, Hispanic participants using hearing aids were more likely to report less-than-optimal satisfaction with the quality of healthcare compared to non-hearing aid users (PR: 1.18; 95% CI, 0.99-1.42).

Conclusions: No clear modification by race of the association of hearing and satisfaction with care was found but differences in the association between hearing aid use and satisfaction with care were found. However, current work is limited by potentially low sensitivity measures of the hearing loss. Future work including clinical measures of hearing would be useful in understanding the complex intersection of hearing loss and racial inequities in the U.S. health care system.

Category: Hearing Loss / Rehabilitation

Poster #: 110

Hearing Data Collection in a Large Population-Based Study

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Objectives: The Longitudinal Study of Aging in India-Diagnostic Assessment of Dementia (LASI-DAD) is a nationally representative epidemiologic survey of Indians 60 years and older that aims to characterize late-life cognition and dementia. The goal of this pilot was to develop a quality control and quality assurance plan and assess the feasibility of pure-tone audiometry within the LASI-DAD field-assessment protocol. Considerable obstacles included the novelty of this process to field staff, potential for ambient noise in the testing environments, and the COVID-19 pandemic that prevented travel for in-person training. These results reflect integration of hearing measures in a large population-based study in low to middle income country, which are hopeful to be generalizable in similar studies.

Design: Six hearX HearTest smartphone-based portable audiometers were procured. Quality assurance actions included creation of a picture-based, language appropriate Manual of Operations with full instruction scripts and a training plan. Three videoconferences were held to give didactic information and motivate field staff with importance of assessment, a walk-through of protocol, and live feedback on practice assessments. In addition, an on-demand professional video detailing the assessment protocol was created to support field staff. Quality control included monitoring data in real time using an algorithm that assessed quality of results based on ambient noise present during testing. This algorithm, provided by hearX, flagged for review length of the assessment (>12 minute test sessions were flagged), and improbability of results (threshold patterns of at least 2 changes >30 dB among adjacent frequencies). Also by algorithm, thresholds were obtained at 500, 1000, 2000, 4000, and 8000 Hz.

Results: Data collection was completed on 46 participants aged >60 years over an 18-day period. The mean 4-frequency better-ear pure-tone average for participants was 35.5 dB (SD = 14.9, range 17.5-88.75). Per World Health Organization categories, 9 had normal hearing, 24 mild hearing loss, 10 moderate hearing loss, and 3 severe. Mean assessment time was 5.9 minutes (SD 1.8, range 3.8-11.75). Importantly, mean duration of assessment dropped from 8.6 minutes (n=6) during the first 5 days of data collection to 5.3 minutes (n=7) during the last 5 days of assessment. Univariate regression revealed a -.19 minute change in assessment duration per day of data collection (95% CI -.31 to -.09; p<0.001). Only 12 of 460 thresholds indicated noise warnings (all at 500 Hz). Lastly, 3 participants had results flagged as improbable and an audiologist review panel approved audio results for 2 of 3. Overall, 45 of 46 participant results were deemed acceptable.

Conclusions: These represent beginning efforts to incorporate hearing measures into the first-in-kind LASI-DAD cohort. Initial pilot results pleased the study principal investigators and hearing metrics will be collected on the 3000+ participants in the next round of data collection – eventually yielding the largest nationally-representative, pure-tone audiometry dataset among older Indians. These results demonstrate proper training of field staff in a large population-based study yield valuable data. Replication of integrating hearing measures in similar studies is necessary to confirm generalizable the necessity of hearing in dementia and aging research.

Category: Hearing Loss / Rehabilitation

Poster #: 111

Dual Sensory Loss Increases Delirium Risk in Medicare Beneficiaries

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Objectives: Delirium is an acute change in cognition and attention that is associated with higher cost of care, longer length of stay, and higher risk of mortality and negative long-term health outcomes (e.g., dementia, frailty). In fact, estimates suggest delirium accounts for \$164 billion in annual excess health care expenditures. Sensory loss may increase the risk of delirium during hospitalization due to isolation from an individual's environment and limited communication. The aim of this study was to characterize the association of sensory loss and delirium in a large sample of hospitalized Medicare beneficiaries.

Design: Cross-sectional analysis of pooled administrative claims data from the 2016 and 2017 cycles of the Medicare Current Beneficiary Survey (MCBS), a nationally representative survey of Medicare beneficiaries. Participants included 2638 Medicare beneficiaries (mean age = 77 years) who experienced a hospitalization during the survey years. Incident delirium was identified using a validated claims-based algorithm with mild sensitivity and high specificity against gold standard measures. Exposure was self-reported trouble with vision and hearing in daily life (with sensory aids if applicable). Participants were categorized as having vision loss only, hearing loss only, and dual sensory loss. Logistic regression models adjusted for demographic, socioeconomic, and health covariates were used to characterize the association of sensory loss and delirium. Risk ratios for delirium were calculated using modified Poisson regression with robust variance. Further, risk ratios were used to calculate risk differences of delirium per 1000 individuals.

Results: Among 2638 hospitalized Medicare beneficiaries, 870 (33.0%) had no sensory loss, 642 (24.3%) had hearing loss only, 428 (16.2%) had vision loss only, and 698 (26.5%) had dual sensory loss. In the sample, 214 (8.1%) experienced delirium. A higher proportion of those with dual sensory loss (11.9%) experienced delirium relative to those with hearing loss only (6.5%), vision loss only (7.7%), and those without sensory loss (6.4%). Multivariate logistic regression revealed those with dual sensory loss had 50% higher odds (OR=1.50, 95% CI 1.03-2.18) of experiencing delirium relative to those without sensory loss. Vision and hearing loss alone were not associated with delirium. In addition to dual sensory loss, age, history of stroke, and diagnosis of dementia were associated with delirium. Risk difference calculation revealed 25 excess cases of delirium per 1000 Medicare beneficiaries with dual sensory loss compared to the group without sensory loss.

Conclusions: Dual sensory loss was associated with delirium in a large sample of hospitalized Medicare beneficiaries. Importantly, unlike other associated risk factors in the current analysis (age, stroke, dementia), dual sensory loss may represent a modifiable risk factor to target for delirium prevention. Notably, current work is limited by self-report measures and a lack of gold standard delirium metrics. It is likely the current work underestimates the incidence of delirium as well as sensory loss, particularly hearing loss which is often underreported. Future work is needed with clinical measures of hearing and vision among hospitalized adults as well as time-demanding but best-practice delirium measures to better understand the association.

Category: Hearing Loss / Rehabilitation

Poster #: 112

Hearing Loss and Engagement in Social Activities in Older Adults

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Objectives: Two-thirds of adults aged 70+ have hearing loss (HL), which is associated with dementia, depression, and social isolation; however, the pathways underlying these associations are not well understood. Given the importance of hearing for communication, HL could possibly lead to withdrawal from participation in social activities. However, few population-based studies have tested this hypothesis. We evaluated if participation in favorite activities with social components differs by HL and whether HL impacts someone's ability to participate in their favorite activity. We hypothesized that HL is associated with older adults participating in individual (vs. social) activities.

Design: Cross-sectional analysis of Round 1 (2011) of the National Health and Aging Trends Study (NHATS), a nationally representative population-based study in Medicare beneficiaries aged 65+. Participants in this analysis were dementia-free with complete exposure, outcome, and covariate data. Favorite activity was self-reported (i.e., "Thinking about all the activities you do these days, what is your favorite activity?"). For analysis, participation in a social (vs. individual) activity was defined as requiring interpersonal interaction (e.g., socializing with others in person) and modeled as a binary variable (yes/no). Difficulty participating in favorite activity was defined as self-report of health or function preventing engagement (i.e., "In the last month, did your health or functioning ever keep you from this activity?") and modeled as a binary variable (yes/no). Functional HL was considered present if participants self-reported deafness, hearing aid use, inability to hear well enough to use the telephone, or inability to hear well enough to carry on conversation in a room with the television or radio playing. Multivariable-adjusted logistic regression was used to estimate the odds ratios (OR) and 95% confidence intervals (CIs) of participation in an individual (vs. social) favorite activity, by HL status, and, in a separate model, reporting difficulty participating in favorite activity due to health or function, by HL, adjusting for age, race & ethnicity, sex, education-level, smoking, diabetes, hypertension, and number of IADL impairments.

Results: In 7,135 participants (39% \geq 80 years; 58% female; 22% Black, Non-Hispanic; 54% \leq high school), prevalence of a favorite individual (vs. social) activity was 68% and 67% among those with and without HL, respectively. After full adjustment, the OR of a favorite individual (vs. social) activity was 1.11 (95% CI: 0.96, 1.28), suggesting 11% increased odds of a favorite activity that does not require socialization among those with HL compared to those without, however the CI crosses the null value. HL was associated with 55% greater odds of reporting limited ability to participate in favorite activity (OR=1.55; 95% CI: 1.31, 1.85).

Conclusions: Among older adults with HL, strained communication could make participating in social activities challenging, potentially prompting behavioral alterations that minimize social participation. Our findings suggest that, although this may be occurring, many older adults are choosing to participate in their favorite social activities despite experiencing health or function-related difficulty. However, those with HL are more likely to experience these difficulties. Whether HL is contributing to this difficulty, and, if so, if treatment may change this relationship to promote continued social engagement should be investigated.

Category: Hearing Loss / Rehabilitation

Poster #: 113

Self and Informant Reports of Hearing Handicap in Older Adults

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Objectives: Information from family and friends about a person's hearing ability is commonly reported to be a significant factor in their decision to seek hearing health care. However, there is little information in the literature regarding if or how this information is assessed and how it relates to standard clinical measures of hearing loss and self-reported hearing handicap. The goal of this study was to determine the relationship between self-reported and informant-estimated (e.g. family member/loved one) hearing handicap in a group of older adults with a range of hearing abilities. An additional goal was to compare measures of hearing handicap with behaviorally assessed audiometric thresholds. We predicted that informant-rated hearing handicap would have a stronger relationship with the participant's behaviorally measured hearing thresholds than the participant's self-rated hearing handicap, particularly for those with mild to moderate hearing losses.

Design: A total of 100 older adults, aged 65 and older, and 100 informants were recruited for the study. Informants were defined as the participant's most frequent communication partner and included spouses, friends, and adult children. Participants and informants independently completed the 15-item Speech, Spatial, and Qualities of Hearing Scale (15iSSQ) and Hearing Handicap Inventory for the Elderly (HHIE). Participants subsequently completed a comprehensive audiometric assessment including otoscopy, tympanometry, pure tone air and bone conduction thresholds, word recognition, and the QuickSIN. Participants' hearing ability was quantified as their 4-frequency (0.5, 1, 2, 4 kHz) better ear pure tone average (BEPTA).

Results: Preliminary analysis ($n=32$) revealed moderate correlations between self- and informant-scores on the HHIE ($r = .66, p = .142$) and the 15iSSQ ($r = .45, p = .079$), meaning that study participants and their communication partners had similar perspectives on the participant's hearing capability. However, these correlations did not reach significance, likely due to high variability and small sample size. Self-reported HHIE scores were also moderately correlated with participants' BEPTA ($r = .44, p = .152$) while informant-reported HHIE scores were only weakly correlated with participants' hearing thresholds ($r = .23, p = .281$). These

preliminary results are contrary to our expectations, as we hypothesized significant and stronger relationships between hearing handicap and pure tone hearing sensitivity, especially for informant reports. When we analyzed the relationship between self versus informant reported hearing handicap and BEPTA for only participants with mild to moderate hearing losses (n = 18; BEPTA 25-55 dB HL), similar moderate correlations, with nominal but as yet insignificant differences, were identified. We expect results will be more conclusive with an increased sample size.

Conclusions: This study highlights the importance of involving family/loved ones in the clinical care of hearing difficulties in older adults. Clinicians may consider including informant measures when gathering case history, to better understand how well the patient's frequent communication partners describe their hearing ability. Furthermore, informant reports may especially be important in situations where an individual has other health concerns (eg. cognitive decline) that may influence their self-perception. By utilizing the patient's communication partner in developing shared communication goals, this may lead to more effective aural rehabilitation for older adults experiencing hearing difficulties.

Category: Hearing Loss / Rehabilitation

Poster #: 114

Community Health Workers as Patient-Site Facilitators in Teleaudiology Hearing Aid Services

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Objectives: The purpose of this study was to investigate the feasibility of Community Health Workers as patient-site facilitators in synchronous teleaudiology-delivered hearing aid services.

Design: The study community was a medically underserved, rural, US-Mexico border area that has been identified as having limited local resources for audiology. A total of 28 adults (ages 55-89 years) met the following eligibility criteria: bilateral hearing loss in fitting range of study devices, passing score on cognitive screener, no medical contraindications for hearing aid fitting. Individuals were randomized to one of two teleaudiology intervention arms that differed at the level of the patient-site facilitator (Community Health Worker or university student). Synchronous (real-time) teleaudiology hearing aid services took place with participants located at a rural community health center and the clinician located an office 70 miles away. The primary outcome was communication self-efficacy, measured by the Self-Efficacy for Situational Communication Management Questionnaire (SESMQ). Secondary outcomes included hours of hearing aid use (datalogging) and health-related quality of life (SF-12). Outcomes were collected immediately before the hearing aid fitting, and up to 17 weeks post-fitting.

Results: For the primary outcome (communication self-efficacy), both groups (Community Health Worker and control) significantly improved from baseline to post-fitting, and no significant difference between groups was observed. Regarding quality of life (SF-12), scores did not significantly change from baseline to follow-up for either group. For datalogging, at the short-term follow-up, Community Health Worker group participants wore their hearing aids for more hours/day on average compared to participants in the control group, but the difference between groups at the long-term follow-up was not significant.

Conclusions: Although previous research across a number of healthcare areas has identified that Community Health Workers can help improve patients' health access, there is a paucity of evidence of their collaboration with audiology to improve outcomes for hard-of-hearing older adults. This study showed that a novel teleaudiology hearing aid service delivery model, with trained Community Health Worker as patient-site facilitators, is feasible. Future efficacy and effectiveness trials are warranted, potentially leading to a significant improvement in access to hearing care for rural and medically under-resourced communities.

Category: Hearing Loss / Rehabilitation

Poster #: 115

General and Situation-Dependent Traits Predict Readiness to Pursue Audiologic Intervention

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Objectives: Previous research has provided inconsistent findings about the relationship between hearing aid self-efficacy (HASE) and personality. One explanation might be that HASE is task specific and personality traits are considered more general. This research examined how adults responded to surveys about their personality traits, affective states, and self-efficacy when they were assessed "in general" and in hearing-related contexts. Additionally, the frequently assessed aspects of hearing aid (HA) success such as help seeking, adoption, benefit, and satisfaction are only available for assessment in later stages of an individual's hearing health journey. Research has suggested that readiness to change might be the first step in defining success. This study also identified the significant predictors of readiness and estimated the mediating and moderating effects of patient traits on the relationship between perceived hearing difficulties and readiness to pursue intervention.

Design: Sixty-two adults with self-reported hearing difficulties and no experience with HAs participated in this descriptive study. Perceived hearing-related handicap was assessed as the primary predictor and readiness to change as the outcome variable. Self-efficacy, personality, and affect were assessed in general and in hearing-related situations. Affective state was assessed in four listening situations ("At a social event", "Asking directions", "At a doctor's appointment", and "At home"). Paired t-tests and repeated measures ANOVA with Holm-Sidak corrections were used to assess differences between general and listening-situation-dependent traits. Moderation and mediation analyses were performed to identify significant predictors of readiness as well as to test the effects of HASE and affective states.

Results: Results of paired t-tests demonstrated no significant differences between general and situation-dependent self-efficacy or personality traits ($p > .05$). However, our participants reported significantly less positive and more negative affective state in listening situations compared to in general ($p < .001$). When HASE was considered in the model, individuals with greater hearing handicap, high HASE, and more agreeable personality were more ready to pursue help ($F(9,52)=7.83, p < .0001$). Moderation analyses demonstrated that the relationship between hearing handicap and readiness didn't change as a function of HASE, when personality traits and duration of hearing loss were controlled. When affective states were considered, individuals with greater hearing handicap, low Conscientiousness personality, and less negative affect in the "Asking Directions" situation were more ready to pursue help ($F(14,48)=6.79, p < .0001$). Mediation analyses demonstrated that the relationship between hearing handicap and readiness could not be explained by their relationships with affective states.

Conclusions: This study supports the recommendation that audiologists' early efforts should be geared towards understanding each patient's attitudes, feelings, and behaviors about changing their readiness to change their hearing health behaviors in their daily lives. Future research should focus on exploring the associations between personality traits and affective states in different stages of hearing health journey to decide whether an assessment of these factors is needed. Also, if audiologists could accurately identify their patient's readiness in initial appointments, it could help identify the specific needs of that patient and might facilitate the provision of a more individualized, client centered approach to audiologic rehabilitation.

Category: Hearing Loss / Rehabilitation

Poster #: 116

A Nationwide Survey of VA Audiologists' Perspectives on Ototoxicity Management

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Objectives: It is well established that the platinum-based chemotherapies used to effectively treat many types of cancers are ototoxic. A growing body of evidence indicates that these essential therapies are often prescribed without the patient being fully aware of the hearing health-related risks, including hearing loss, tinnitus, changes in balance, or associated quality of life impacts. Additionally, patients receiving life-saving treatment may not self-refer for audiologic care. In the US Veterans Health Administration (VA), hearing healthcare is a high priority, as hearing loss is among the top three service-connected disabilities for Veterans receiving compensation. It is estimated that more than 10,000 VA patients are treated with platinum-based

chemotherapies each year; however, the current state of ototoxicity management (OM) in VA is not well-defined. A questionnaire survey was developed using the Consolidated Framework for Implementation Research (CFIR) and administered to VA audiologists and service chiefs/leads nationwide. It aimed to gain an understanding of the frequency of patients evaluated who were receiving ototoxic cancer treatments; what services were routinely performed; the perceived importance of those services, the relative importance of various drug side-effects; and perspectives on barriers and facilitators associated with OM processes at their clinic. Questions asked specifically about OM in the context of cancer patients receiving cisplatin, carboplatin, oxaliplatin, or radiation therapy. The results of this survey will inform the development of an implementation toolkit to support the provision of high-quality OM in VA.

Design: A 26-item survey comprised of multiple-choice, multiple-selection, rating-scale, ranking, and open-ended questions was developed for administration to VA audiologists and their department chiefs/leads and reviewed by a team of experts for face validity. Questions were mapped to one of three domains in the CFIR [Outer Setting: Veteran's needs and resources; Inner Setting: Audiology and oncology providers' network and communications; Characteristics of Individuals: Audiology and oncology providers' knowledge, beliefs and prioritization of OM]. Requests for participation by VA audiology service chiefs/leads and one other audiologist per department were emailed to 128 individuals identified as Audiology and Speech Pathology Service leadership across the VA's 18 regional systems of care. The survey was accessed through a link to the secure web-based questionnaire platform, Qualtrics. Responses were anonymous. Descriptive statistics and deductive thematic analysis were used to analyze the data.

Results: There were 63 respondents, including at least one from each VA region. Roughly half reported having fully adopted baseline, monitoring, and follow-up testing for patients receiving cisplatin and carboplatin. There was disagreement regarding the appropriate frequency of hearing monitoring for these patients, although all respondents reported that a baseline evaluation was very or extremely useful, and nearly all felt some form of monitoring was necessary. Respondents identified barriers that conformed to three themes: Interdisciplinary care coordination/identifying patients; audiology workload; and lack of protocol.

Conclusions: Sixty-three VA audiologists or service chiefs/leads provided their perspectives on current OM practices for VA cancer patients at-risk for chemotherapy-related ototoxicity. This information provides a benchmark against which progress can be measured, helps define achievable/valued aspects of OM, and can facilitate goal alignment among audiology and oncology providers.

HEARING SCIENCE / PSYCHOACOUSTICS

Category: Hearing Science / Psychoacoustics

Poster #: 117

Evaluating Remote Tools to Determine Headphone Use During Online Testing

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Objectives: Online research offers many benefits, such as access to larger and more diverse participant pools, timing flexibility, and reduced travel for participants. However, there are also limitations to online research. The anonymous and self-administered nature of online participation reduces experimental control and creates an

over-reliance on self-reported measures. Auditory tasks require a quiet environment for participants to hear the desired signal clearly. Using headphones during auditory tasks is beneficial in blocking out extraneous noise while also providing a more consistent, controlled desired signal to the ear compared to speakers. However, confirming headphone use is typically subject to self-report reliability, with the exception of recently-developed objective tests for headphone use. The current study aims to evaluate the efficacy of two online headphone screening tasks for individuals with hearing loss: one intensity-discrimination three-alternative forced-choice task (antiphase task), and a second auditory percept three-alternative forced-choice task (Huggins pitch task).

Design: Fifty three adults (aged 20-84 years; 32 female, 21 male) with access to a computer with speakers, internet, and headphones were recruited through an established lab database to participate in an online study. Participants were divided into “normal hearing” and “hearing loss” groups based upon previously obtained audiograms, with normal hearing classified as a 4-frequency (.5, 1, 2, and 4 kHz) pure tone average ≤ 25 dB. Researchers guided participants through the experiment over video conferencing and confirmed compliance with intended procedures. This provided ground-truth information on headphone use which we could use to evaluate the headphone screening measures.

Results: Although the headphone screenings were somewhat effective, they were imperfect, failing to identify several listeners who were not wearing headphones (antiphase task: 26.4%; Huggins pitch task: 13.2%). When listeners were wearing headphones, the passing rate for the antiphase task was 86.8% and 69.8% for the Huggins pitch task. The accuracy did not statistically differ between listeners with normal hearing and those with hearing loss for either test, antiphase task: $t(52) = 7.6, p < 0.001$; Huggins pitch task, $t(52) = 6.5, p < 0.001$.

Conclusions: Being able to objectively test for headphone use is important for non-monitored research and clinical applications, including potential future applications in remote assessment. Although these existing tests offer some information about headphone use, in general their accuracy was suboptimal in our real-world test of their effectiveness. The lack of statistical differences between listeners with normal hearing and listeners with hearing loss suggests that as tests improve in accuracy they may be useful for a variety of patient populations.

Category: Hearing Science / Psychoacoustics

Poster #: 118

Effects of Spatial Separation and Voice Difference on Masking Release

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Objectives: This study is aimed at comparing the unmasking benefits (i.e., masking release) due to spatial separation and voice difference between English- and Mandarin-Chinese-speaking normal-hearing listeners. It is hypothesized that the amount of masking release based on spatial separation is comparable between English- and Mandarin-Chinese-speaking listeners, whereas that based on voice difference is not. Specifically, Mandarin-Chinese-speaking listeners may take greater advantage of F0 difference in voice to perform speech segregation, of which the advantage can be partially attributed to the lexical function that F0 contour serves in Mandarin Chinese. Alternatively, null findings may indicate that lexical processing based on F0 contour in Mandarin Chinese does not contribute to speech segregation based on F0.

Design: Two experiments were conducted. Experiment I compared the masking release from spatial separation and voice difference between Mandarin Chinese and English using the coordinate response measure in the two

languages. Experiment II compared the masking release in conditions where tonal information is either preserved or removed (i.e., by flattening F0 contour) for the Mandarin Chinese stimuli. Twenty native English-speaking normal-hearing adults participated in Experiment I and 20 native Mandarin-Chinese-speaking participants participated in both Experiment I and II.

Results: The spatial release from masking was comparable between English- and Mandarin-Chinese-speaking listeners ($F(1,35)=1.33$, $p=0.256$). On average, both groups benefited approximately 12 dB from spatial separation in multiple-talker babbles but none in speech-shaped noise. The masking release due to voice difference was larger in Mandarin-Chinese-speaking listeners ($F(1, 35)= 118.21$, $p<0.0001$), with an average of 13 dB compared to 5 dB in English-speaking listeners. Further, flattening the tones of the Mandarin Chinese stimuli reduced the masking release due to voice difference by about 5 dB ($F(1,133) = 77.93$, $p<0.0001$), but did not have an effect on masking release due to spatial separation ($F(1, 171)= 1.99$, $p=0.161$).

Conclusions: Both English- and Mandarin-Chinese-speaking listeners benefit similarly from spatial separation in speech segregation, with Mandarin-Chinese-speaking listeners taking greater advantage of voice difference for speech segregation over English-speaking listeners. This advantage can be partially attributed to the lexical role that F0 contour plays in tonal languages such as Mandarin Chinese.

Category: Hearing Science / Psychoacoustics

Poster #: 119

Effect of Bandwidth Reductions on Vowel-Variable and Consonant-Variable Word Recognition

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Objectives: This study evaluated effects of reduced spectral bandwidth on speech-in-noise and speech-in-speech recognition for adults with normal hearing. This was accomplished via high-pass and low-pass filtering of target speech and competing noise or speech maskers. Word recognition was evaluated in three-alternative forced-choice format for two conditions: one in which recognition depended on consonant perception (consonant-variable sets), and one in which recognition depended on vowel perception (vowel-variable sets). There were two primary predictions. First, recognition of vowel-variable targets was expected to be more detrimentally affected by high-pass filtering compared to recognition of consonant-variable words. The reverse pattern of results was expected when low-pass filtering was applied. Second, we anticipated that reducing the bandwidth of target and masker speech would interfere with segregation of target and masker speech. Thus, effects of filtering were expected to be greater in the speech masker relative to the noise masker. when both the target and masker speech were passed through the same filter.

Design: Fourteen adults aged 19 to 50 with self-reported normal hearing participated in this study. Participants were recruited through word of mouth in Michigan and Nebraska. Participants were provided with a tablet computer, high-quality headphones, and a sound card to complete remote testing. An adaptive procedure was used to estimate masked speech recognition thresholds (SRTs). Participants listened to words in either competing speech-shaped noise or two-talker speech. Participants were asked to indicate the word they heard by touching one of three pictures displayed on the tablet screen. Two sets of target stimuli were used to complete

testing, one where the three potential targets varied by vowel, and another where the three potential targets varied by consonant. Target stimuli and masker stimuli varied in bandwidth: they were either high-pass filtered, low-pass filtered, or full bandwidth. Fourth-order Butterworth filters with a 1700-Hz cutoff were used. These three conditions were completed for each set of target words in each masker (12 conditions total).

Results: A repeated-measures ANOVA indicated significant main effects of target word set, masker type, and bandwidth. The two-way interaction between target word set and bandwidth was significant. While low-pass filtering had a larger detrimental effect than high-pass filtering on recognition of consonant-variable words, the opposite pattern was observed for vowel-variable words. The two-way interaction between masker type and bandwidth was also significant, reflecting larger effects of reduced bandwidth in competing speech relative to competing noise. Neither the two-way interaction between target word set and masker type nor the three-way interaction was significant.

Conclusions: These results are consistent with the expectation that access to low-frequency information is more important for vowel recognition, and high-frequency information is more important for consonant recognition. It is also consistent with the idea that audible bandwidth is more important for speech-in-speech recognition than speech-in-noise. The ability to observe these effects with a picture-pointing task has implications for future research with children.

Category: Hearing Science / Psychoacoustics

Poster #: 120

Visual Plasticity and Functional Communication in Hearing Aid Users

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Objectives: Functional communication outcomes for hearing aid users are dependent on both speech recognition and satisfaction. Though numerous studies have examined the impact that different intrinsic (e.g. age, degree of hearing loss) and extrinsic (e.g. technology, cost) factors have on hearing aid satisfaction, findings have not always been consistent. One factor that could account for this inconsistency is differences in the way the brain processes sensory signals. There is evidence for changes in sensory processing following deafness, but little is known about how these changes impact functional communication outcomes for hearing aid users. This exploratory research aims to investigate the role of neural plasticity in the variability of functional communication outcomes for hearing aid users.

Design: A prospective study was completed with nine bilateral hearing aid users with symmetric sensorineural hearing loss (planned N = 30). A visual temporal order judgement task, a McGurk illusion task, and an auditory, visual, and audiovisual speech in noise task were used to characterize performance, unisensory weighting, and integration of auditory and visual stimuli. Since behavioral similarities may mask differences in underlying neural differences, functional near infrared spectroscopy (fNIRS) was also used to assess neural activation in response to visual and audiovisual stimuli. These behavioral and objective measures were then compared to standardized measures of patient satisfaction with hearing aids.

Results: Behavioral data suggest that there is not only a large degree of variability in functional communication outcomes for hearing aid users, but also a large degree of variability in visual temporal thresholds (39 - 219

milliseconds) and audiovisual integration (audiovisual gain = 47-285%). Early findings indicate that higher levels of audiovisual integration may be associated with less satisfaction with communication outcomes ($r = -0.44$). Multivariate analyses including the fNIRS data is ongoing and will be discussed once data collection is complete.

Conclusions: Differences in neural plasticity may contribute to the variability in functional communication outcomes for hearing aid users. In turn, this understanding could influence clinical decision making in determining both hearing aid and cochlear implant candidacy.

Category: Hearing Science / Psychoacoustics

Poster #: 121

Binaural Hearing and the Integration of Auditory and Vestibular Cues

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Objectives: Vestibular science research has recently taken a particular interest in how auditory cues serve as an additional input that aids in postural stability, gait and balance, and self-motion. Recent evidence shows that auditory information may be used to improve all of these, but the process is poorly understood and requires further research. One potential route for auditory input is the binaural system, which supports sound localization and is critical in facilitating speech segregation from background noise. We hypothesize that same auditory scene analysis process that improves speech understanding in noise might support self-motion perception as well while negating visual input.

Design: In this project, psychophysical thresholds were measured over a range of frequencies (0.1, 0.2, 0.5 and 1.0 Hz) during self-rotation without spatial auditory stimuli, rotation of a sound source around a stationary listener, and self-rotation in the presence of an earth-fixed sound source using the Knowles Electronics Mannequin for Acoustics Research (KEMAR). The binaural mannequin was used to record the auditory information available during the Shayman et al. experiments, and the recordings were analyzed to extract interaural timing differences (ITDs), interaural level differences (ILDs), and monaural changes.

Results: Analysis involved comparing the sizes of these cues with maximum displacement and peak velocity at the different rotation rates (.1, .2, .5, and 1 Hz). All the auditory cues were strongly related to maximum displacement, regardless of rotation rate, while the same peak velocities yielded differently sized cues for the different rotation rates.

Conclusions: The binaural auditory system is critical in facilitating sound localization and speech segregation from background noise. The contributions of interaural timing differences (ITDs) and interaural level differences (ILDs) are at the basic levels of understanding and the study of binaural hearing. The vestibular system integrates peripheral sensory information from vestibular, somatosensory, visceromotor, and visual receptors as well as motor information from the brainstem, cerebellum, and cerebral cortex. We are learning that audition plays a role in this, and research studies are suggesting the same, but the existing data does not rise to the level of evidence required for the auditory system be incorporated into the existing models that describe the components of balance. Recent studies have demonstrated that peak velocities are important in the

identification of physical cues, whereas our results demonstrate that maximum displacement is more significant for the identification of auditory cues. In our experiment the visual system was denied, and data suggests that the auditory system can contribute sensory information to self-motion perception. That is confirmation of our initial hypothesis where the auditory system is contributing to the mapping of the environment.

Category: Hearing Science / Psychoacoustics

Poster #: 122

Spectral Weighting Analysis of Sound Localization with Simulated EAS Listeners

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Objectives: The phenomenon of binaural interference refers to the reduction of binaural cue sensitivity in a target stimulus in the presence of a spectrally remote interferer. One perspective is that binaural interference reflects obligatory perceptual weighting of the interfering spectral region. We hypothesize that this process limits access to binaural cues when different types of information are delivered to different regions of the cochlea, e.g., combined electric-acoustic stimulation (EAS). No previous studies have explicitly measured perceptual weights on target and interferer components in a binaural interference paradigm. In this study, we measured spectral weighting functions (SWF) for localization of combined low-frequency noise and high-frequency click train stimuli. The stimuli were selected to mimic the acoustic and electric components delivered to the apical and basal cochlear regions in EAS listeners.

Design: Ten normal-hearing adult listeners completed a simple localization task using the Oculus Quest 2 virtual reality (VR) headset with calibrated headphones. Stimuli were seven-component complexes composed of three noise bands (100-200, 200-400, and 400-800 Hz) and four Gabor click trains centered at 1, 2, 4, 8 kHz. The contribution of each component (noise band or click train) to the localization responses was expressed as a perceptual weight. In Experiment 1, the localization target consisted of both the low-frequency noise and the simulated electrical (high-frequency click-train) components. Some conditions omitted specific components to observe how the perceptual weights shift as the degree of spectral overlap is manipulated. In Experiment 2, the simulated electrical component served as a distractor while the low-frequency target was localized. Perceptual weights on both target and distractor components were measured to identify spectral regions of obligatory versus selective weighting under conditions of binaural interference.

Results: Experiment 1 revealed SWFs with greatest weight in the 400-800-Hz noise band and the 1-kHz click train. That frequency region (around 800-1000 Hz) roughly corresponds to the "ITD dominance region" described in previous literature. Results also indicated that the perceptual weights shifted when spectral overlap was manipulated. Omitting single or multiple frequency components tended to increase weights on neighboring components. Experiment 2 revealed greater individual variability. Some participants were able to shift weight off of the distractor and onto the target components. Others, however, maintained SWFs that were similar to Experiment 1. That is, those participants appeared more susceptible to binaural interference. A few participants displayed changes in this pattern over the course of Experiment 2, shifting from high to low weights on distractor components over time.

Conclusions: 1) Remote testing with a commercial VR headset and headphones successfully produced data with high reliability and consistency with prior lab-based tests. This is promising for future testing in binaural cue

research and remote data gathering. 2) SWFs revealed localization weights that favored frequencies in the range 400-1000 Hz, coinciding with the "ITD dominance region" identified previously in a large number of studies. 3) Individuals differed significantly in their ability to selectively weight target vs distractor components. That variability is consistent with differences in susceptibility to binaural interference.

Category: Hearing Science / Psychoacoustics

Poster #: 123

Neural Bases of Cognitive Demand During Language Processing in Noise

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Objectives: Using neural oscillations of the EEG recent research has shown that alpha power increases in cognitively demanding tasks, including processing sentences in which incoming words are difficult to predict based on the previous semantic context (i.e., low predictability sentences). It is well known that noise increases cognitive demand during language processing; however, its effects on alpha power are unknown. The objective of this study is to understand the extent to which competing noise and semantic predictability interact and modulate alpha power during sentence processing, and how alpha power relates to speech perception in noise skills of a group of young adults with normal hearing. We hypothesize that noise will result in an increase in alpha power, regardless of semantic predictability. However, high-predictability contexts will result in increased alpha power relative to low-predictability in quiet and noise conditions, facilitating speech perception. We also hypothesize that smaller changes in alpha power between quiet and noise conditions will predict greater speech-in-noise performance across predictability contexts than greater changes in alpha power.

Design: We are recruiting 30 college students with typical development and normal hearing. During EEG participants listen to 7-word sentences and need to repeat the final word of the sentence. Sentences are presented in quiet (100 sentences) in noise (+5 dB signal-to-noise ratio; 100 sentences). Fifty low-predictability and 50 high-predictability sentences are randomly assigned to each listening condition. In addition, participants complete the Multi-SNR R-SPIN test, which allows us to obtain behavioral speech perception in noise measures for low and high-predictability semantic contexts.

Results: We collected preliminary data on six participants. Results showed that confirming our hypotheses, alpha power increases in noise during sentence processing with respect to quiet. Replicating previous studies, we find increased alpha power in low-predictability compared to high-predictability contexts. However, contrary to our predictions we do not find greater alpha power in low- compared to high-predictability in noise conditions. Analyses on the relationship between our neural and behavioral measures are ongoing.

Conclusions: Background noise has a strong effect on alpha power, suggesting increased cognitive demand during sentence processing in noise in respect to quiet conditions. Although data collection is ongoing and results will have to be confirmed with the larger sample, we suggest that alpha power can be used as a biomarker of cognitive effort during language processing. Children and adults with hearing loss are known to experience disproportionately high levels of listening effort and fatigue during language processing in noise. Therefore, alpha power could be used to study the effects of noise on neural language processing in these clinical populations. Finally, the lack of differences between low- and high-predictability contexts in noise conditions might be explained by the heavy load on cognitive resources provided by masked speech stimuli.

That is, because alpha power increases drastically in noise, capturing subtle alpha changes between low- and high-predictability contexts might be difficult to observe. We anticipate that increasing statistical power with the larger sample might allow observing differences between low and high predictability contexts in the presence of background noise.

HEARING TECHNOLOGY / AMPLIFICATION

Category: Hearing Technology / Amplification

Poster #: 124

Evaluation of an Artificial Intelligence Algorithm for Assistive Listening Devices

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Objectives: The purpose of this study was to assess a human-in-the-loop deep reinforcement learning algorithm that incorporates the listening preferences of individuals with hearing loss to develop a personalized amplification strategy. Studies have shown that as many as half of hearing aid users prefer different values than those prescribed. The current standard of care for hearing aid users is to prescribe amplification values such as the Desired Sensation Level version 5 (DSLv5). This prescriptive approach is based on the average needs of individuals who are hearing impaired. Among these average-based prescriptive values, a critical component is the compression ratio. The compression ratio is used to apply non-linear gain across the frequency range so that sounds that are below threshold are audible and sounds that exceed threshold have a slower amplification ramp to balance both audibility and comfort. In order to personalize DSLv5 prescriptive values, we used a human-in-the-loop deep reinforcement learning (DRL) framework to modify compression ratios based on user feedback. The results revealed that across all adult participants, the DRL-derived values were preferred over DSLv5 prescribed values. In addition to being preferred, DRL values had no negative impact on word recognition and increased performance slightly. This application of DRL technology could be used to achieve optimal fitting of hearing aids and assistive listening devices that are responsive to user preferences.

Design: This study recruited 10 adult participants. Audiometric pure tone thresholds and DSLv5 amplification targets were used to determine the initial compression values. Following audiological evaluation, participants completed a computerized listening task through hearing aids connected to a computer via Bluetooth (gain and hearing aid features were disabled). Participants listened to 30 different spoken sentences. Each sentence played twice, first using the initial compression ratios and then again using a second set of compression ratios determined by DRL. The order of the standard and DRL sentences were randomized. For each sentence pair, the participant was prompted to select which presentation they preferred. These data were used to train the algorithm. Based on the participant's response, the software adjusted the compression ratios and a new sentence was played. The participants completed this task 3 times and the user's preferred compression ratio was determined by averaging the preferred compression ratio of the 3 trials. Once the preferred compression ratio was identified, the user's preferences were compared to the standard DSL v5 compression ratios. Finally, the participants completed a word recognition task using the custom compression ratios and again using the DSLv5 compression ratios to assess potential differences in word recognition performance (NU-6) between the two approaches.

Results: All study participants preferred the DRL-derived compression ratios when compared to the DSLv5 fitting formula values. In addition, we found that when using the DRL-derived values, word recognition scores were the same or better than scores obtained from the DSL v5 fitting formula.

Conclusions: The results presented here suggest that DRL-derived personalized compression ratios not only optimize comfort but maintain or improve audibility as assessed by the NU-6.

Category: Hearing Technology / Amplification

Poster #: 125

Hearing Loss, Hearing Aids, and Satisfaction with Health Care

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Objectives: Hearing loss has been previously associated with decreased satisfaction with healthcare; however, it is unknown whether hearing aids mitigate this association. The aim of this study was to characterize the association of hearing and satisfaction with health care as well as explore whether hearing aids are protective of decreased satisfaction with care among those with hearing difficulty.

Design: This cross-sectional analysis pooled the 2000-2018 cycles of the National Health Interview Survey, a cross-sectional annual health survey of civilian, non-institutionalized Americans. Satisfaction with quality of health care over the past year (very satisfied, satisfied, dissatisfied, very dissatisfied), self-report trouble hearing with a hearing aid (excellent, good, a little trouble, moderate trouble, a lot of trouble), and hearing aid use (yes/no) were all collected. Consistent with previous work, satisfaction with care was recoded to optimally satisfied (very satisfied) and less-than-optimally satisfied. We used poisson regression with robust error variances to obtain prevalence ratios among the general population to explore the association of hearing and satisfaction and the created models limited to those with hearing difficulty to characterize the impact of hearing aid use. Models included demographic, socioeconomic, and health status covariates.

Results: Of the total sample of 137,202 respondents, 61,830 (45.06%) participants reported excellent hearing, 48,646 (35.45%) reported good hearing, 16,339 (11.91%) reported little trouble hearing, 6,687 (4.87%) reported moderate trouble hearing and 3,714 (2.71%) reported a lot of trouble hearing. Participants who reported a lot of trouble hearing had the highest proportion of hearing aid use (59.67%). Relative to those who reported excellent hearing, participants with good hearing (Prevalence Ratio [PR] = 1.20; 95% Confidence Interval [CI], 1.18-1.23), a little trouble hearing (PR = 1.27; 95% CI, 1.23-1.31), moderate trouble hearing (PR = 1.30; 95% CI, 1.24-1.36), and a lot of trouble hearing (PR = 1.26; 95% CI, 1.18-1.33) had higher prevalence of reporting less-than-optimal satisfaction with the quality of healthcare. In an analysis limited to those reporting hearing difficulties, participants who reported hearing aid use were less likely to report less-than-optimal satisfaction with the quality of healthcare compared to nonusers (PR = 0.85; 95% CI, 0.81-0.91).

Conclusions: In a nationally representative survey hearing loss was associated with decreased satisfaction with care. This may be mediated by poor patient-provider communication. Importantly, hearing aid use appears to

mitigate the impact of hearing loss on lower satisfaction with care among those with hearing loss. These findings further support calls for accommodations for hearing loss in health care settings to address health disparities. The findings are limited by the cross-sectional nature of the work, self-report hearing, and potential unmeasured confounding. Future work using gold standard hearing measurement is needed.

Category: Hearing Technology / Amplification

Poster #: 126

Examining Barriers to Satisfaction in Adults Receiving Over-the-Counter Hearing Aids

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Objectives: This exploratory study aimed to investigate barriers to satisfaction experienced by adults using hearing aids obtained via an over-the-counter service delivery model. The primary goal was to see if any unique barriers to satisfaction would be identified in participants using over-the-counter hearing aids that extend beyond well-researched barriers to satisfaction previously identified in a traditional audiology service delivery model.

Design: This project utilized data from a larger study being conducted at Vanderbilt and the University of Iowa that aims to assess the viability of different hearing aid service delivery models for adults with mild to moderate hearing loss. Interview data from thirty-two adults randomly assigned to the over-the-counter group and thirty-five adults randomly assigned to the audiology best practice group in the larger study were analyzed using qualitative content analysis. Specifically, the study focused on what participants did not like about the study hearing aids and services. Meaning units were extracted from participant responses and grouped into themes.

Results: Many barriers to satisfaction were consistent with previously identified themes for traditional audiology service delivery models. However, additional themes related to service delivery were present only for the over-the-counter group. In general, these themes were related to 1) The lack of service; 2) Inadequate education related to app use; and 3) Lack of user comfort with device use. A lack of barriers was reported for some individuals in both the audiology best practice and over-the-counter groups.

Conclusions: While this exploratory study only examined a single over-the-counter service delivery model, the preliminary results suggest additional barriers may be present in some of these models. With final guidance from the FDA (Food and Drug Administration) for over-the-counter hearing aids imminent, understanding barriers to satisfaction will help audiologists to better support over-the-counter patients. In addition, it is expected that such data may help audiologists to identify which patients are better suited for different types of full-service, limited service or over-the-counter models. These findings suggest a need for future studies examining the barriers to satisfaction in patients utilizing a variety of over-the-counter or limited-service hearing aid service models.

Category: Hearing Technology / Amplification

Poster #: 127

Relationship Between Working Memory, Compression, and Beamformers in Ideal Conditions

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Objectives: Previous research has shown that individual working memory is associated with wide dynamic range compression (WDRC) benefit, especially in adverse listening conditions. However, much of this research is limited to omnidirectional hearing aid settings and unrealistic listening conditions (i.e., fixed and co-located speech and noise), whereas most hearing aids are fit with directional processing that may improve the listening environment, and that typical environments contain speech and noise signals in different spatial locations. Moreover, directional processing varies in the amount of benefit across listening conditions. Thus, we need to understand how the relationship between working memory and WDRC changes in the presence of microphone directionality and different spatial conditions. This study focused on a "strong" microphone directionality (beamformer) that is known to significantly improve the signal-to-noise ratio (SNR) but can highly limit spatial cues. The objectives of this study were to determine a) whether there is an association between individual working memory ability and speech intelligibility in noise with WDRC processing in the presence of a beamformer in an ideal spatial condition and b) to characterize how this relationship may be different from the effects of working memory studied with omnidirectional processing and co-located conditions.

Design: Listeners with bilateral mild to moderately severe sensorineural hearing loss repeated low-context sentences (00) mixed with 4-talker babble, presented across a realistic range of SNRs in co-located (0-degrees) and spatially separated (180-degrees) conditions. A wearable hearing aid, customized to the listener's hearing level was used to present four signal processing combinations of microphone directionality (omnidirectional or beamformer) and WDRC speed (fast-acting or slow-acting). Other advanced hearing aid features were turned off. Individual working memory ability was measured using the reading span test. A signal fidelity metric was used to quantify envelope distortion in the processed signal across experimental conditions with respect to a linearly processed signal in quiet.

Results: Results to date show that speech intelligibility improves at higher SNRs, and with a beamformer in spatially separated noise as expected. In the spatially separated condition and with omnidirectional settings, observed trends suggest a benefit with fast-acting WDRC for listeners with higher working memory and a detriment for listeners with lower working memory, compared to slow-acting WDRC. In contrast, there is no observed effect of WDRC speed in the presence of a beamformer regardless of the listener's working memory ability. These observations are supported by the signal fidelity data. Furthermore, in the omnidirectional condition, individuals with lower working memory may be more disadvantaged with fast-acting WDRC than slow-acting WDRC in co-located noise relative to spatially separated noise. Statistical analyses on the complete dataset will be conducted to confirm these patterns.

Conclusions: As seen in previous research, individual working memory ability may affect benefit with WDRC and omnidirectional processing in co-located noise conditions. However, individual working memory ability may not affect benefit with WDRC in the presence of a beamformer in ideal spatial conditions. Future work will include a comprehensive set of microphone directionality and realistic spatial conditions. [The research is supported by NIH-K01DC018324].

Category: Hearing Technology / Amplification

Poster #: 128

Alpha-Band Dynamics in Hearing Aid Wearers Performing the Repeat-Recall Test

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Objectives: To Investigate the dynamics of alpha activity in hearing aid wearers during a speech-in-noise test. Alpha activity relates to functional inhibition of task irrelevant brain areas. During listening, alpha power increases with the difficulty of listening conditions, especially in task-irrelevant visual cortex, suggesting it can be a proxy for listening effort. The Repeat-Recall Test (RRT) is a clinically friendly tool for assessing listener speech-in-noise performance under a variety of listening conditions. Different configurations of the RRT are, by design, differentially demanding of listeners' hearing and cognitive abilities. For example, the RRT tests sentence level speech-in-noise recognition over a range of realistic SNRs (-5 to 15 dB). Listeners may also be asked to remember what was heard for later recall, placing additional demands on auditory memory. To study context effects, RRT speech materials comprise complementary sets of sentences that are either semantically meaningful (high context) or re-arranged to be syntactically valid but semantically meaningless (low context). As such, the RRT offers a unique opportunity to study the dynamics of alpha activity in hearing aid wearers as they engage with listening across a range of difficulty. Moreover, alpha activity may offer insight into the demands of different RRT conditions and validate/disambiguate listener ratings of effort as surveyed after each RRT trial.

Design: The RRT speech materials were presented at 65 dB SPL from the front (0°) and continuous noise was simultaneously presented from the back (135° and 225° azimuth). The RRT involved 4 stages. In the repeat stage, listeners were presented with a sequence of 6 pre-recorded sentences in noise at one of four (-5, 0, 5, 10 dB) fixed SNRs. Listeners were tasked with repeating each sentence as it was heard and committing the content of the sentences to memory. After the final sentence, listeners were prompted to recall the sentence content. Listeners then rated how effortful they found the listening situation (10-point scale) and estimated their willingness to stay in the noise (tolerable time). This was done for both high and low context sentences. The RRT sequence was also re-administered while omitting the recall stage. During all testing, EEG was collected using 19 electrodes to monitor alpha wave activity. Linear mixed effects models were used to evaluate the fixed effects of the different RRT conditions (i.e., SNR, recall, context) on the alpha activity measured in 18 hearing aid wearers with bilateral sensorineural hearing loss.

Results: Preliminary analyses suggest that alpha power over occipital electrode sites was reduced with increasing SNR, but more so when listeners were not required to recall. Consistent with expected cognitive demand, alpha power was also lower in the "no recall" versus "recall" configuration, especially over frontal electrodes. Effects of context were nuanced and interacted with recall and SNR conditions.

Conclusions: Alpha power follows the expected difficulty of different speech-in-noise test configurations in hearing aid wearers. The RRT is a useful clinical tool for assessing listeners across a variety of difficult listening conditions.

Category: Hearing Technology / Amplification

Poster #: 129

Impacts of a Community-Based Hearing Aid Recycling Program

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Objectives: The goal of this project is to collect exploratory data on the impacts of participating in a hearing aid (HA) recycling program for low-income hearing-impaired adults and their significant others (SO). The research objectives are to: (1) Describe the HA fitting process experienced by participants; (2) Identify facilitators and barriers encountered during the fitting process; (3) Explore the advantages and disadvantages of the HA recycling program; (4) Assess the satisfaction towards the recycled HA received (technology and services); (5) Assess social participation and the feeling of security after the HA fitting.

Design: A cross-sectional case study design combining qualitative and quantitative data sources have been used. Individual semi-structured interviews have been carried out with 15 users of a HA recycling program and 15 of their SO. After the interviews, participants completed two questionnaires to assess their satisfaction about HA and services received, and their social participation and feeling of security with the use of HA. Participants were recruited with the help of the community organization that offers the HA recycling service. A qualitative content analysis has been performed on the data collected during the interviews. A descriptive group analysis has been carried out on quantitative data (i.e., socio-demographic data, satisfaction, social participation, feeling of security).

Results: Data collection and analyses are underway. Preliminary results (n=8) suggest that users and SO are globally satisfied of the HA recycling program (HA and services). The process of getting a HA from that program was seen as easy and efficient. The reception of users and their SO, the support offered by the personnel and the free HA provided were mentioned as the main advantages of the program. Those advantages facilitated the fitting process. The main disadvantages of the program mentioned by participants were the characteristics of the HA obtained (ex. different size or colour, lack of compatibility with a second HA or accessories), routine inspection and maintenance costs not covered, and the distance between users' home and offices where services are dispensed. The most important obstacle to participating in the HA recycling program was that most audiologists and hearing aid specialists were not aware of its existence. In consequence, they did not mention it as an available alternative for clients unable to pay for their HA. Clients had to seek the information by themselves, or with the help of community support networks. Participants reported an improved social participation and feeling of security after obtaining HA.

Conclusions: From the preliminary results analyzed, the community-based HA recycling program under investigation may represent a valuable and beneficial alternative for the acquisition of HA for low-income hearing-impaired adults. Some improvements might be made to the program to review how the recycled HA are matched with clients' needs, to expand the network of offices collaborating with the program, to increase its visibility for clients and professionals, and to encourage professionals to refer more clients to it. Updated results, interpretation, and conclusions will be presented at the conference.

Category: Hearing Technology / Amplification

Poster #: 130

Hearing Aid Problems: Are you Getting the Full Story?

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Objectives: Almost 30% of hearing aid owners do not use their hearing aids regularly due to ongoing problems, such as those relating to physical discomfort, handling, and performance. These device-related problems are both avoidable and rectifiable through modification to the hearing aid or improving skills relating to use and maintenance of the hearing aid. This program of research sought to better understand (i) hearing aid problems, (ii) help-seeking behaviours of adult hearing aid owners, and (iii) whether annual hearing aid review appointments are effective in improving hearing aid problems.

Design: Study One: Used concept mapping methodology, including group interview with adult hearing aid owners and audiologists, to develop a framework for understanding hearing aid problems. Study Two: Survey of 413 hearing aid owners across Australia to explore the prevalence of and factors associated with hearing aid problems in adult hearing aid owners, and help-seeking behaviours for hearing aid problems. Study Three: Used a randomized controlled cohort design to compare rates of hearing aid problems before and after clients attended a hearing aid review appointment.

Results: Study One: 160 problems that arise following hearing aid fitting were identified across four concepts: 1) Hearing Aid Management; 2) Hearing Aid Sound Quality and Performance; 3) Feelings, Thoughts and Behaviours and 4) Information and Training. Study Two: Almost all participants (98%, n=405) indicated that they were experiencing at least one of the hearing aid problems included on the survey. The number of hearing aid related problems reported by participants ranged from 0 to 25 (of a possible 26), with a mean of 10 problems. The three most reported problems were related to difficulty hearing in noisy environments, hearing in windy environments, and understanding certain voices. Participants had reported less than half (46.33%) of the total problems identified to their clinic (range = 0 to 100%, mean = 43.40, SD = 13.92). Participants who reported experiencing a greater number of hearing aid problems also reported lower levels of hearing aid benefit, and satisfaction with their hearing aids. Study Three: A significant reduction in participant's self-reported hearing aid problems was recorded following the attendance at the hearing aid review appointment, suggesting that these appointments appear to be effective in improving hearing aid problems.

Conclusions: Findings highlight the need for clinicians to designate more time and resources towards assessing, and addressing hearing aid owner's device-related problems.

Category: Hearing Technology / Amplification

Poster #: 131

Subjective and Objective Evaluation of Telecoil Mode in Different Environments

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Objectives: There are numerous wireless assistive listening technology options available to hearing aid wearers, such as remote microphones, smartphone streaming, hearing loops and neck loops. It is important for clinicians to understand the relative efficacy of these systems as well as their patients' understanding of and attitudes towards using them. We conducted lab-based speech recognition tests and ran a field study that culminated in a

simulated movie theater/auditorium listening experience for user-behavior observation. Participants also provided subjective ratings of the listening modes for different types of audio.

Design: We conducted a series of experiments comparing the standard hearing aid microphone configuration to wirelessly delivered audio, among two diverse patient groups: behind-the-ear (BTE) hearing aid users (n=14) and completely-in-the-canal (CIC) hearing aid users (n=14). In particular, we conducted speech recognition tests comparing hearing aid users' performance with standard hearing aid microphone configurations to that with a proprietary remote microphone system, a hearing loop system using a telecoil function, and a smartphone audio streaming application. In addition, we conducted a field trial of hearing aids that concluded with a simulated movie theater and auditorium listening experience. At the time of initial hearing aid fittings, a subset of the participants was provided with an orientation and demonstration of the hearing loop and telecoil functionality. When the participants (n=28) returned, two months later, for the simulated movie theater and auditorium visit, we made observation of which participants utilized their telecoil hearing aid setting. We also probed the participants regarding the presence or absence of hearing accessibility signage at the entrance to the auditorium used for the simulation. Participants (n=28) also provided subjective rating comparisons of the standard hearing aid microphone configuration and a hearing loop/telecoil setting. For these comparisons, BTE hearing aid users (n=14) utilized the embedded telecoil of the hearing aids, while the CIC hearing aid users (n=14) accessed the hearing loop with an external telecoil included in a multifunction, wireless hearing aid accessory. The participants rated each of the listening modes for different types of audio of interest, including live speech, British film, American film, symphonic music, and music with vocals.

Results: Assistive listening devices significantly improved speech recognition in noise. Telecoil function was strongly preferred for various types of audio and in various environments. Most patients forgot to use the telecoil function and/or didn't know a hearing loop was available. In-office "Loop" demonstrations and counseling improved participant awareness and information retention. Responses suggest that experience using telecoil functions would impact participants' future purchasing decisions

Conclusions: Findings from these observations validate the recommendation of assistive listening systems, even for patients with mild and moderate degrees of hearing loss, and underscore the importance of counseling and in-office demonstration of assistive listening devices.

PEDIATRIC AUDIOLOGY / OTOTOLOGY

Category: Pediatric Audiology / Otology

Poster #: 132

A Predictive Tool: Infant Speech Perception and Emerging Language Skills

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Objectives: The objective of our research is to examine the relationship between behavioral speech perception measured in at 7 and 30 months of age using a clinically recommended tool and later expressive language measured 33 months of age. Children who are hard of hearing (CHH) demonstrate benefits of early detection

and intervention though improved language and academic success. Unfortunately, there is still a gap in language achievement for CHH compared to their typical hearing peers. Studies of children with normal hearing (CNH) suggest that infant speech perception is predictive of later language abilities. We expand this line of research by examining the relationship among CHH and CNH. Developing and refining a tool to assess infant speech perception has the potential over time to aid in modification of habilitation strategies during a period of rapid language learning. We hypothesize that infants with higher speech perception scores (d') will exhibit more advanced emerging language abilities at 33 months.

Design: Infant speech perception abilities were assessed using a conditioned head turn procedure to contrasts /a-i/ and /ba-da/ at three presentation levels (50, 60 and 70 dBA SPL), and the Open and Closed Speech Perception Test score used in percent phonemes correctly produced. Discrimination scores were used as a continuous variable. At 33 months, a spontaneous at-home language was recorded, transcribed, and analyzed. We examined the validity of early infant speech perception and later speech perception assessed at 30 months of age. Speech perception measures served as unique predictor of later measures of sentence diversity obtained from the spontaneous language sample (at 33 months). Preliminary data includes speech perception assessed in infancy and toddlerhood (CHH=37, CNH=42) as predictor variables of expressive language at 33-months of age (CHH=29, CNH=19).

Results: Data analysis includes linear regression between behavioral speech perception scores and number of unique sentences produced at 33 months. Preliminary analysis indicates there are significant relationships between early speech perception abilities and later language abilities.

Conclusions: Results suggest that both measures of speech perception are correlated and related to later spoken language abilities across groups. Establishing the relationship between infant speech perception and later language abilities is a necessary first step to establishing clinically valid tools of infant speech perception. Data collection has been completed in CNH and will be completed among the CHH cohort by time of presentation.

Category: Pediatric Audiology / Otology

Poster #: 133

Prevalence of Executive Function Deficits in Children with Hearing Loss

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Objectives: Disrupted access to auditory input early in life may alter the development of executive function-based cognitive processes, such as attention, inhibition, and working memory. When compared to their normal-hearing peers, children with hearing loss have been shown to perform more poorly on measures of executive function in laboratory settings. Deficits in executive function may place children with hearing loss at greater risk for delayed language development and poorer speech recognition in background noise. However, the prevalence of executive function deficits in children with hearing loss is not well understood. An enhanced understanding of the prevalence of executive function deficits in children with hearing loss is necessary to further inform the clinical management of these children. The purpose of this study was to quantify the

prevalence of executive function deficits in children with hearing loss using a mixed-methods approach of retrospective chart review and prospective parent report via questionnaire.

Design: A retrospective chart review was conducted for over 600,000 children 4 to 21 years of age who were seen at Stanford Children's Health since 2014. Children either had normal hearing or diagnosed hearing loss in at least one ear. Executive function deficits were characterized as diagnosed (e.g., attention-deficit/hyperactivity disorder; ADHD) or subclinical defined as documented reports of attention-related concerns without explicit diagnosis. In addition, parent questionnaire responses were obtained for 76 children 4 to 21 years of age who were seen in the Pediatric Otolaryngology department at Stanford Children's Health. Children either had normal hearing or diagnosed hearing loss in at least one ear. Questionnaire items assessed various aspects of children's selective attention, such as their ability to pay attention in quiet versus noisy environments.

Results: Retrospective chart review revealed the prevalence of diagnosed ADHD is greater in children with hearing loss (5%) compared to children with normal hearing (2%). Subclinical executive function deficits were also found to be more prevalent in children with hearing loss (9%) compared to children with normal hearing (0.5%). Consistent with this, parents of children with hearing loss reported higher rates of attention difficulties (9%) than parents of children with normal hearing (5%), with even greater differences observed for reported attention difficulties in noisy environments (56% of children with hearing loss versus 21% of children with normal hearing). Other factors that may impact the prevalence of executive function deficits in children with hearing loss, such as hearing loss characteristics and hearing device use, will also be discussed.

Conclusions: Executive function deficits are more prevalent in children with hearing loss than children with normal hearing. These results were consistent regardless of whether executive function deficits were diagnosed (i.e., ADHD), observed subclinically, or reported via parent questionnaire. This has significant negative implications for the ability of children with hearing loss to function in complex acoustic environments. Future research is needed to determine the mechanisms behind the increased prevalence of executive function deficits in children with hearing loss.

Category: Pediatric Audiology / Otology

Poster #: 134

Longitudinal Changes in Hearing Thresholds in Children Who are Hard of Hearing

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Objectives: Children who are hard of hearing (CHH) can have progressively worsening hearing threshold as they age. This study analyzed changes in hearing thresholds in CHH to determine: 1) whether CHH show longitudinal changes in hearing threshold; 2) if thresholds shifts relate to functional outcomes, such as speech perception and spoken language; and 3) if changes in threshold coincide with changes ear canal acoustics (i.e., real-ear-to-coupler difference [RECD]). We predicted overall worse thresholds in children as they age, with a small percentage showing significant shifts. We also predicted that increase in thresholds will coincide with decrease in functional outcomes and increase in ear canal size (i.e., larger RECD values).

Design: We examined pure-tone hearing thresholds (250 - 8000 Hz octave intervals) in 285 CHH via a longitudinal dataset (Outcomes of Children with Hearing Loss Consortium studies). All children had assessments from at least two time points (maximum = 8 time points). Baseline measurements occurred at age 5 months - 10 years and final measurement occurred at age 1 - 11 years. We investigated functional outcomes via assessments of auditory skills (e.g., LittleEARS), speech perception (e.g., PBK) and spoken language (e.g., PPVT, CASL). We also examined ear canal acoustics via measured and age-related average RECDs. We calculated differences between thresholds at individual frequencies and in three-frequency pure-tone average.

Results: CHH showed statically significant changes in threshold over time, but these changes were not clinically significant. A small percentage of children showed clinically significance increase in hearing thresholds over time. These clinically significant changes were associated with changes in speech perception but not language. Changes in thresholds were not strongly correlated with changes in RECD values.

Conclusions: Most CHH have relatively stable hearing thresholds over time. CHH with significant changes in their thresholds need modification to their hearing technology (e.g., re-programming of hearing aids) to maximize audibility and to preclude functional changes in communication.

Category: Pediatric Audiology / Otology

Poster #: 135

Childhood Listening and Associated Cognitive Difficulties Persist through Early Adolescence

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Objectives: Listening difficulties (LiD) in children with clinically normal audiograms are prevalent and associated with a range of learning problems, including speech/language and attention deficits. Children may have LiD at any age, but the longitudinal progression of LiD remains unclear. A key outcome measure for LiD is the 'Listening in spatialized noise - sentences' test (LiSN-S) that enables some separation between sensory and cognitive skills in speech perception in a noisy environment. In the previous cross-sectional study, we found that 6- to 13-year-old children with LiD, based on a caregiver structured report (ECLiPS), had lower cognitive and LiSN-S performance than typically developing (TD) children. Our objective is to present longitudinal data of the ECLiPS scores, cognitive test results, and LiSN-S performance in the same TD and LiD children to ask whether LiD is developmentally transient or persistent. We hypothesize that LiD persists through early adolescence.

Design: This is a prospective case-control longitudinal study entitled 'Sensitive indicators of childhood listening difficulties' (SICLID). Behavioral and physiological data were collected from consented and assented children initially aged 6-13 years at baseline (Wave 1), and two (Wave 2) and four (Wave 3) years later. Caregivers of

all children completed the ECLiPS, a reliable and validated questionnaire, at each visit. Children in both groups completed the LiSN-S and NIH-Toolbox cognitive battery at each visit. We assessed whether the poor listening ability and low LiSN-S and cognitive performance in the LiD group persisted using multivariate mixed-effect models. We also developed a multivariate model to predict listening abilities using longitudinal data.

Results: Of 169 enrolled participants in SILCID, 146, 98, and 30 children completed required testing in study visits of Waves 1, 2, and 3, respectively. The mean ages of the participants at each visit were 9.5, 12.0, and 14.0 years old. ECLiPS total age-corrected scaled scores in LiD did not improve statistically across time ($p = .1223$). All LiSN-S and NIH-toolbox test scores were poorer in the LiD group than the TD group throughout the study period (mixed-effect models, group effect: $p < .012$, no significant interaction between group x Wave). Maternal education, four LiSN-S scores, and ten NIH-toolbox age-corrected standard scores were significantly positively associated with the ECLiPS total scaled score. A parsimonious prediction model for ECLiPS total scaled score (pooled across groups) was created using the data of Waves 1 and 2 by backward selection. The final model included maternal education, LiSN-S Spatial advantage, and NIH Toolbox total composite score. This model explained 44% of the variance in ECLiPS total scaled score.

Conclusions: Children with LiD but normal audiograms have persistent listening difficulties, challenges in competing speech tasks, and poor cognitive performance through early adolescence. The degree of LiD can be predicted by maternal education, cognitive processing, and spatial listening skills.

Category: Pediatric Audiology / Otology

Poster #: 136

Co-occurrence of Autism and Reduced Hearing in Children

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Objectives: 1:54 children in the U.S. have autism spectrum disorder (ASD). Compared to the general population, reports in the literature suggest that ASD is more prevalent in children who have reduced hearing based on small clinical samples. Moreover, there is evidence that ASD diagnosis is delayed for children with reduced hearing compared to children with normal hearing sensitivity. Delays in the differential diagnosis process can lead to poor developmental outcomes because the presence of reduced hearing can significantly complicate acquisition of language for children who are dually diagnosed with reduced hearing and ASD. In order to improve development outcomes for this population, the purpose of this study was to leverage a large data repository of children receiving audiological care to (1) determine the prevalence of ASD in children with reduced hearing, and (2) evaluate delays in ASD diagnosis based on hearing status.

Design: We examined audiogram, auditory brainstem response (ABR), and diagnosis data from 116,974 children (0-18 years) who received care at Children's Hospital of Philadelphia, Vanderbilt University Medical Center, or Boston Children's Hospital. 5,889 children had a diagnosis of ASD in their medical record. Hearing status was defined based on the first available audiogram that had sufficient air conduction thresholds (500, 1000, 2000 and 4000 Hz) for a classification. Reduced hearing was defined as a pure-tone average (PTA-4) > 25 dB HL. If audiogram data were not available, hearing status was determined based on ABR thresholds. Child

age was computed for three time points: first encounter in the audiology clinic; first encounter with sufficient threshold data to allow determination of hearing status; and first encounter with an ASD diagnosis code.

Results: 1:20 children had an ASD diagnosis in our sample. For children classified as having reduced hearing, the occurrence rate of ASD was 1:26. Delays in ASD diagnosis were seen for children with reduced hearing. For children under 4 years, 86% of them had their first encounter in the audiology clinic prior to an ASD diagnosis being entered into their medical record. For this age group, ASD diagnosis was delayed by an average of 6 months for children with reduced hearing compared to children with normal hearing sensitivity.

Conclusions: To our knowledge, this is the first study to document the high number of children seen in audiology clinics who ultimately receive an ASD diagnosis. This finding has significant implications for preparing a workforce and equipping providers with tools so that this population is adequately served. Moreover, audiologists and other deafness professionals require additional training on ASD red flags and screening tools because children with reduced hearing have a higher risk of ASD than what is seen in the general population. Future efforts are needed to develop targeted strategies to reduce delays in ASD diagnosis for young children with reduced hearing.

Category: Pediatric Audiology / Otology

Poster #: 137

Exploring Parents' Experiences with Infant Hearing-Loss Screening and Detection

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Objectives: We aimed to explore hearing parents' early experiences with their children's newborn hearing-loss (HL) screenings and later diagnoses. We hypothesized that the subjective accounts from parents about their infants' early hearing detection experiences would reveal several different themes that emerged from the same, mandated 1-3-6 experience in families across the United States (US).

Design: This study employed a prospective, cross-sectional qualitative design utilizing semi-structured narrative interviews. We used snowball sampling given the relatively low incidence of pediatric hearing loss. When we reached saturation (i. e. the point in which no new themes arose) during our thematic analysis no further sampling was needed. Saturation was reached at Interview #4. Thus, we interviewed 13 adults (12 females; 1 male) with typical hearing, who parented a child with HL and resided in various locations across the US for our study.

Results: Via thematic analysis, we uncovered participants' subjective early experiences relating to their children's early HL screening and diagnosis. Two, mutually exclusive, major themes emerged from the data: (1) hearing healthcare experiences and (2) parents' early experiences with their child's HL. Subthemes were also uncovered. Three emergent subthemes related to healthcare experiences included: (1) downplayed newborn hearing screening referrals, (2) clinician-centered care, and (3) medical expenses and health coverage. The three subthemes of the second theme were: (1) parent-to-parent support, (2) "mom guilt", and (3) a new reality.

Conclusions: In the present study, parents shared their diverse experiences surrounding their infants' early hearing screening and HL diagnosis. Themes uncovered in this study support the need for a family-centered approach to the hearing screening and HL diagnosis process in the US. As seen in research studies with families

navigating pediatric chronic illness other than HL, family-centered approaches to health care improve not only the care experience but also the clinical outcomes of children with HL and their families. A first step toward such improvements in the field of hearing health care could be encouraging clinicians to create a space of respect and trust that invites families to share their stories. In order for families to benefit from such storytelling, clinicians must be ready to mindfully listen to the families' stories and allow the narratives to influence their collaborative clinical care. Additionally, clinicians could create opportunities for parent-to-parent support for hearing parents affected by newborn HL diagnosis. Previous studies have found benefit in these connections, and the current study's narratives support similar benefits. Such steps would move the field of pediatric hearing health care toward a family-centered approach that could address concerns and expectations surrounding newborn hearing screening and HL while simultaneously working toward the Joint Commission on Infant Hearing's goals of the earliest HL detection, diagnosis, and intervention for these children.

Category: Pediatric Audiology / Otology

Poster #: 138

Noise Exposure and Hearing Difficulty in 16-19-Year-Old US Youth

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Objectives: To examine noise exposure for United States youth, 16-19 years old, in relation to self-reported hearing trouble, the Gallaudet functional hearing loss scale, tinnitus, and selected Hearing Handicap Inventory items.

Design: We analyzed information collected in the home via computer-assisted personal interviews for the National Health Examination and Nutrition Survey (NHANES), 2017-2020, conducted by the National Center for Health Statistics, CDC. Cluster, multistage random sampling was used to obtain a nationally representative sample of the civilian, non-institutionalized population. The hearing health component of NHANES is sponsored by NIDCD, NIH and NIOSH, CDC. We analyzed responses from 963 youths, 16-19 years old, weighted to represent 16.6 million US youths. Hearing status was reported as: excellent, good, a little trouble, moderate trouble, a lot of trouble, or deaf. Functional hearing was determined using the Gallaudet sequential questions ("Can you usually hear and understand what a person says without seeing his or her face if that person ["whispers", "talks in a normal voice", or "shouts"] to you from across a quiet room, or "speaks loudly into your better ear"? Bothersome tinnitus was asked: "In the past 12 months, have you been bothered by ringing, roaring or buzzing in your ears or head that lasts for 5 minutes or more?" Hearing Handicap Inventory questions were: "How often do you have difficulty hearing and understanding if there is background noise, for example, when other people are talking, TV or radio is on, or children are playing? and "How often does your hearing cause you to feel frustrated when talking to members of your family or friends? Participants responded: a) always, b) usually, c) about half the time, d) seldom, or e) never. For the analysis, we categorized the responses as "half the time or more often" versus "seldom or never". Environmental noise exposure was asked: "Have you ever been exposed to very loud noise or music for 10 or more hours a week?" If yes, the length of time exposed was asked. Very loud was defined as noise so loud that you had to shout to be understood or heard 3 feet away.

Relative risk was assessed using logistic regression models to estimate odds ratios (OR) and 95% confidence intervals (CI), adjusting for age, sex, and race/ethnicity.

Results: Self-assessed hearing trouble prevalence was 8.2% and for the Gallaudet scale 11.0%. Exposure to very loud environmental noise was strongly related to self-assessed hearing trouble, OR=4.7 (CI: 2.1, 10.4); moderate or worse problems with tinnitus, OR=3.8 (CI: 2.1, 7.0); and the Gallaudet scale determined hearing loss, OR=2.2 (CI: 1.2, 4.1). Tinnitus was associated with very loud occupational noise, OR=2.4 (CI: 1.1, 5.1), and very loud environmental noise, OR=1.8 (CI: 1.1, 3.2). Tinnitus described as a moderate or worse problem was associated with frustration when talking to family or friends, OR=4.6 (CI: 1.4, 14.7).

Conclusions: Very loud noise exposure in American youth is associated with multiple hearing problems, including self-assessed hearing difficulty and tinnitus. The findings reinforce the need for hearing loss risk factor prevention early in life.

SPEECH PERCEPTION

Category: Speech Perception

Poster #: 139

Effects of Entropy in Real-World Noise on Speech Perception

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Objectives: Traditional tests of speech-in-noise perception use artificial background noise, leading to results that do not generalize to real-world scenarios. Of particular importance, hearing aid features that show benefit in laboratory tests do not show analogous benefit in the real-world. There is a significant need for improved ecological validity in laboratory and clinic speech-in-noise tests, particularly with respect to the types of noise used, to better understand speech perception in real-world noisy environments and the effectiveness of hearing aids. However, the acoustic complexity and random nature of real-world noise poses challenges to its use and the interpretation of results. The purpose of this study was to quantify the acoustic complexity of real-world noise and test the effects of complexity on speech perception in listeners with normal hearing and listeners who use hearing aids.

Design: The complexity of real-world noise from 8 environments from the Ambisonics Recordings of Typical Environments Database was systematically quantified in the time and frequency domains using entropy. Entropy describes the complexity of a signal by quantifying its predictability. Twenty-five segments of noise the length of IEEE sentences distributed in entropy from low to high were extracted from each environment. For each participant, target IEEE sentences were drawn randomly, matched with a noise segment in random order, convolved with the room impulse response for that noise segment, and then combined with the noise at a fixed signal-to-noise ratio. Noise was presented at its real-world level. Signal-to-noise ratios were -6 dB for normal hearing participants and 0 dB for participants with hearing loss. Stimuli were presented from an 8-speaker array. Scores for each trial were number of keywords repeated back correctly. Fifteen normal-hearing participants and 25 participants with hearing loss were tested on 200 sentences-in-noise across the entropy distribution in both the time and frequency domains in a trial-by-trial design. Participants with hearing loss completed the experiment in aided and unaided conditions.

Results: Linear mixed effect models showed a significant effect of entropy in the time and frequency domains on number of words correct per trial for participants with normal hearing and participants with hearing loss in the unaided and aided conditions. There was a systematic improvement in speech perception with increases in entropy variance in both time and frequency domains. Effects were larger for entropy in the time domain than the frequency domain for all participants. Effects were larger for the aided than the unaided conditions for participants with hearing loss. Paired t-tests showed that participants with hearing loss performed significantly better in the unaided than the aided conditions.

Conclusions: Entropy in real-world noise affects speech perception for all listeners. Acoustic complexity may contribute to speech perception variance in real-world noisy environments, even when signal-to-noise ratios are similar. Entropy may be more deleterious on speech perception when using hearing aids. Experiments using real-world noise should consider this effect in their design and interpretation.

Category: Speech Perception

Poster #: 140

Possible Cochlear Contribution to Individual Differences in a Speech-in-Noise Task

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Objectives: There is large variation in performance on speech-in-noise (SIN) tasks among individuals with normal audiometric thresholds. Cochlear pathology missed by standard audiometric evaluation has not been ruled out as a possible cause for this variation. A more sensitive measure than audiometric thresholds for assessing the presence of cochlear pathology may be the fine structure of otoacoustic emissions (OAEs). The fine structure of OAEs, given by the peaks and dips in the magnitude of OAEs measured in fine frequency steps, has been shown to provide an early indicator of cochlear pathology and to be predictive of performance in a variety of supra-threshold auditory tasks. The present study used stimulus-frequency OAEs (SFOAEs) to evaluate possible cochlear contributions to individual differences in SIN performance. A relationship found between QuickSIN scores and the signal-to-noise ratio of SFOAE fine structure would be suggestive of a contribution of cochlear outer hair cell pathology to increased difficulty in SIN tasks among individuals with clinically normal hearing.

Design: Fourteen young adults, ages 18 to 29, 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, with the exception of one subject having 30 dB HL threshold at 3000 Hz in the left ear. SFOAE fine structures were measured with a continuous frequency-swept tones (2 sec/octave, 8 sec/sweep) over 48 sweeps from 0.5 to 2.5kHz at 35 dB SPL using OAEToolBox (OTB). Artifact rejection was performed using a least-squares fit (LSF) to a parametric model of the probe-tone and SFOAE. Subsequent analysis averaged the swept-tone frequencies into 50% overlapped, 1/12 octave bands, resulting in 53 data points over 27 bands. This was done to reduce noise in the data from SFOAE fine structure. The features analyzed from the SFOAEs were SFOAE level, noise floor, and SFOAE signal-to-noise floor ratio (SNR). The Quick speech-in-noise (QuickSIN) test was conducted and the dB SNR loss was calculated by averaging two lists for three listening conditions, monaural left and right, and binaural.

Results: A significant correlation for SFOAE amplitude ($r=-0.73$, $p=0.0033$) and SNR ($r=-0.65$, $p=0.011$) was found, where increases in SNR and in amplitude were related to higher QuickSIN scores. However, there was no significant relationship found between QuickSIN scores and noise floor ($r=-0.13$, $p=0.66$).

Conclusions: Contrary to findings by Stiepan et al. (2020), the best predictors for QuickSIN performance among listeners with clinically normal hearing were found to be SFOAE amplitude and SNR, not noise floor. This suggests that reduced function of outer hair cells contributes to increased difficulty in SIN for clinically normal hearing listeners, not physiological noise.

Category: Speech Perception

Poster #: 141

Evaluation of Speech-in-Noise Tests Among Normal and Hearing Loss Listeners

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Objectives: Clinically, there is a lack of routine speech-in-noise testing due to a variety of barriers, including clinician perceived time constraints, uncertainty in which test material is most appropriate for a specific patient, and lack of materials which clearly quantify degrees of speech-in-noise impairment. The speech-in-noise tests available at present use a variety of target signals, such as digits, sentences, or monosyllabic words. Linguistic cues of speech, such as semantics, syntactics, word familiarity and word frequency, influence speech-in-noise performance; and, thus, may add to the clinician confusion about performance interpretation. Our study aimed to evaluate the performance between three speech-in-noise tests with varying linguistic cues currently available for clinical implementation: the Digits in Noise test (DIN), the Words in Noise test (WIN), and the American English Matrix Test (AEMT). To our knowledge, the AEMT, that is available in 15 languages, has yet to be compared to other clinically available speech-in-noise tests. We hypothesized that performance across tests would be correlated for both listeners with normal hearing and listeners with hearing loss. Understanding correlational relationships on these tests will both allow for standardization of degrees of speech-in-noise hearing loss and determine if these tests can be used interchangeably in clinic.

Design: Participants were 27 listeners with normal hearing and 32 listeners with sensorineural hearing loss. All participants were native English speakers. The outcome of interest was performance on the DIN (most linguistic cues), the AEMT (some linguistic cues), and the WIN (least amount of linguistic cues). The DIN and the WIN were presented in the presence of multi-talker babble and used a descending paradigm to derive the 50% correct recognition point using the Spearman-Kärber Equation. The AEMT was presented in an open set in the presence of steady-state speech-spectrum noise and used an automated adaptive procedure to converge to the 50% correct recognition point.

Results: Speech-in-noise performance, reported as the signal to noise ratio (SNR) at which 50% correct word recognition is achieved (SNR-50), for the normal hearing listeners was the following: DIN: -12.6 dB SNR (SD = 1.94), AEMT: -7.8 dB SNR (SD = 4.22), and WIN: 4.8 dB SNR (SD = 1.65). Performance for the listeners with hearing loss was: DIN: -4.9 dB SNR (SD = 2.68), AEMT: -1.5 dB SNR (SD = 4.20), and WIN: 16.6 dB SNR (SD = 5.12). For both groups, performance increased with increasing linguistic cues. Strong positive relationships were found when assessing the materials using a Pearson product moment correlation with r

values of: DIN/WIN: $r=0.849^*$, AEMT/WIN: $r=0.848^*$, and AEMT/DIN: $r=0.729^*$ (*Indicates a p -value <0.001).

Conclusions: All three speech-in-noise test materials were statistically correlated. All three tests provided a reliable representation of speech-in-noise performance, and were considered feasible to implement in the clinic as they took on average less than 7 minutes to administer bilaterally. With additional analyses to determine predicative validity, our findings indicate that these three tests can be used interchangeably in the clinic. Having several comparable speech-in-noise tests allows for a patient-centered approach to test selection.

Category: Speech Perception

Poster #: 142

Can Video Conferencing be a Viable Method to Measure Speech Perception?

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Objectives: Telehealth services in audiology have become more widespread in recent years, especially during the COVID-19 pandemic, allowing a remote delivery of clinical services. Telehealth has proven effective for service delivery to remote and rural locations and was helpful during lockdowns when patients were unable to see clinicians in person. To assure the reliability of clinical services, the aim of the present study was to evaluate a telehealth protocol to measure speech perception skills through virtual meeting applications such as Zoom.

Design: The study followed a non-experimental comparative research design. A total of 20 participants with normal hearing ($PTA \leq 15\text{dB}$) and cognition (MOCA score ≥ 26) participated in the study. Participants' speech perception performance was measured in two sessions, one over a Zoom call and one in-person in the laboratory. Speech perception was measured using Quick Speech in Noise Test (Quick-SIN), Bamford-Kowal-Bench Speech in Noise Test (BKB-SIN), and Word in Noise Test (WIN). Each participant's speech perception was measured twice in the laboratory (same day) by delivering stimuli through a conventional audiometer (LAB) and through a laptop (LAB+H), each time using the participant's personal head/earphones. Each participant was then tested via zoom call (after 7 days) using the same head/earphones they used during the LAB+H session while sitting at a quiet place at home.

Results: Statistical analysis (Kruskal-Wallis for non-normally distributed results) revealed no significant differences between speech perception scores obtained over the Zoom, LAB, and LAB+H methodologies for any of the tests. The researcher found the WIN test was easy to administer over the Zoom compared to Quick-SIN and BKB-SIN. The effects of transducers will be further analyzed to evaluate their effects on test results.

Conclusions: These results suggest that Zoom can be used as a reliable method to measure speech perception with these three tests in situations where conventional methods cannot be utilized. Speech perception measurements over Zoom should only be performed by a trained audiologist as it requires a lot of caution.

Category: Speech Perception

Poster #: 143

Improving Speech Recognition With Transparent Masks and Remote Microphone Technology

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Objectives: This study addressed three research questions: 1. Does the use of ClearMask provide better auditory-visual speech recognition than a surgical mask? 2. Does the use of a ClearMask provide similar auditory-visual speech recognition to that which occurs with the use of no mask? 3. Does the use of remote microphone technology provide improved auditory-visual speech recognition across the three listening conditions (no mask, ClearMask, and surgical mask)?

Design: Auditory-visual speech recognition in noise was evaluated in a repeated-measures design for two face mask types when stimuli were presented with and without remote microphone technology. Adult participants were recruited online via emails, listserv posts, and social media (N=122) and asked to complete the online study in a quiet room on a personal computer, tablet, smartphone, or laptop. If they owned assistive technology, they were asked to use it to optimize acoustic reception. The 40-minute online study included videos of sentences from the Revised Speech in Noise Test spoken in noise by a woman wearing no mask, a surgical mask, or a ClearMask. Conditions with or without remote microphone technology were counterbalanced. Listeners were tasked to type in the last word of each sentence.

Results: Speech recognition in noise performance recorded when the speaker wore a Clear Mask (M=62.7%) was significantly better than when she wore a surgical mask (M=55.5%). However, performance with no mask was significantly better than either mask condition (M=74.6%). When remote microphone technology was used, average scores significantly improved to 92.5%, 93.2%, and 93.8% in no mask, surgical mask, and ClearMask conditions, respectively. Performance in all three face mask conditions with remote microphone technology was commensurate with each other.

Conclusions: Use of remote microphone technology and ClearMask provide significant improvement in auditory-visual speech recognition in noise. This may impact communication in noisy settings such as hospitals, workplaces, classrooms, and especially in public places during the COVID-19 pandemic. To reduce communication barriers caused by noise and face masks, ClearMask and remote microphone technology are strongly recommended.

Category: Speech Perception

Poster #: 144

Cortical Oscillatory and Event-Related Potential Measures of Listening Effort

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Objectives: Listening effort refers to the intentional allocation of attention or other fluid cognitive resources in order to recognize a speech or other auditory signal. Listening effort has been linked to lowered ability to process and remember new information as well as to listening-related fatigue, and is of interest as an indicator of cognitive outcome for people with hearing loss. The current study aimed to evaluate multiple electrophysiological measures of listening effort obtained during perception of spoken sentences in middle-aged

listeners, including electrophysiological measures of oscillatory power in the alpha (8-12 Hz) and theta (4-8 Hz) frequency bands, as well as the P300 or late positive event-related potential. It was hypothesized that each measure would reflect listening effort as a function of signal-to-noise ratio (SNR).

Design: To date, eight middle-aged adults (range = 37 - 65 years) with and without hearing loss (high-frequency (i.e., 1, 2, and 4 kHz) pure-tone average range = 10 - 45 dB HL) have participated in this ongoing study. Participants listened to Bamford-Kowel-Bamford sentences presented in a background of multi-talker babble, and following each sentence were prompted to type the sentence-final word. Sentences were presented at 65 dB SPL, at a range of SNRs relative to an individualized SNR targeting each participant's speech recognition threshold (-3 dB, SRT-50, +3dB, +6dB, +9dB, +12dB). Oscillatory power was quantified as the difference from a pre-stimulus (quiet) baseline, with alpha power measured from posterior electrodes and theta power measured from frontal electrodes. Mean amplitude of the P300 or late positive potential time-locked to sentence onset was measured from posterior electrodes.

Results: Preliminary data indicate that the electrophysiological measure tracked with the SNRs tested, which corresponded to word identification accuracy levels ranging from 50-100 percent. Alpha power and P300 amplitude decreased for lower (poorer) SNRs, whereas theta power increased with decreasing SNR.

Conclusions: These initial findings indicate that the electrophysiological measures tested, alpha- and theta-band oscillatory power and the P300 potential time-locked to speech onset, track with changes in SNR during listening to spoken sentences. Results are consistent with the idea that each of these measures could serve as a neural marker of listening effort during spoken language processing in middle-aged adults.

Category: Speech Perception

Poster #: 145

Speech-in-Noise Processing in Adults with Autism Spectrum Disorder

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Objectives: The purpose of this study was to investigate whether cortical gating is affected by active attention and whether passive or attentive cortical gating serves as a biomarker for speech-in-noise performance in adults with autism spectrum disorder (ASD). Individuals with ASD were expected to demonstrate larger gating percentages than neurotypical peers, indicating less cortical inhibition in passive and active listening tasks. Additionally, this study investigated whether behavioral measures of auditory attention and Acceptable Noise Level predicted speech-in-noise outcomes in individuals with ASD. Neurotypical controls were expected to outperform the ASD group on all measures. Semi-structured interviews and a short form of the Speech Spatial Qualities Questionnaire were also completed to integrate qualitative and quantitative outcomes for a comprehensive understanding of auditory processing and functional performance in multiple contexts.

Design: This study employed a two-group, cross-sectional design to compare neurobehavioral measures of auditory processing. A total of 28 participants (male: 8; female: 20) completed the in-person portion of the present study (neurotypical: 20; ASD: 8). The mean age of the participants was 21.89 years (SD = 2.16). An experimental group and a control group included adults ranging in age from 18-40 years. The control group consisted of participants with no diagnosis of ASD, normal pure-tone hearing sensitivity, normal intelligence, no other disabilities, and use English as a primary language. The experimental group consisted of participants

diagnosed with ASD, normal pure-tone hearing sensitivity, and use spoken English as their primary language. Additionally, nine interview participants diagnosed with ASD completed semi-structured interviews regarding listening capabilities. All participants were recruited from the University of North Texas. The Quick-SIN, Acceptable Noise Level protocol, Conner's Continuous Test of Auditory Attention, and a standard electrophysiological auditory gating paradigm were used to measure behavioral and cortical components of auditory processing. Semi-structured interviews and a short form of the Speech Spatial Qualities questionnaire were used to assess self-reported listening difficulties.

Results: Relative to neurotypical peers, this study revealed that individuals with ASD demonstrated poorer speech perception in noise, less acceptance of noise, and poorer auditory attention skills. Additionally, neurotypicals and listeners with ASD displayed differing amounts of neural inhibition to redundant stimuli. The ASD group demonstrated aberrant patterns of N1 gating in both attention conditions characterized by less gating in the ignore condition and no gating in the attend condition, suggesting differences in N1 responses may be a biomarker for auditory processing deficits in ASD. Finally, semi-structured interviews revealed common themes in self-perceived listening strengths and weaknesses in the ASD group.

Conclusions: The results of this study highlight factors that may contribute to poorer listening performance in adults with ASD including poorer speech recognition and acceptance of noise. Results from this study supported previous findings that differences in N1 gating may be a consistent biomarker for differentiating ASD from neurotypical controls, and differences in evoked responses may aid in pinpointing the locus of breakdowns in ASD. Together, these findings contribute to the understanding of speech-in-noise processing differences in ASD and lay the groundwork for development of gold-standard assessments and treatments for these auditory processing deficits.

TINNITUS

Category: Tinnitus

Poster #: 146

Evaluation of Online Assessment for Tinnitus Pitch in Nonclinical Settings

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Objectives: This research aims to explore the reliability of online testing for tinnitus measurement.

Design: 14 subjects who suffer from tinnitus more than 6 months were tested using two widely used methods for tinnitus measurement: a clinical bracketing method and a pitch similarity rating method. In the clinical bracketing method, subjects listened to a series of pairs of sounds with various frequencies and selected the sound closer to his/her tinnitus pitch. The final choice was recorded as tinnitus frequency for each subject. In the similarity rating method, subjects were presented with sounds of various frequencies one at a time and rated the similarity between what they heard and their tinnitus via a slider. The rating at each frequency was collected and the ratings plotted versus frequency constituted a tinnitus spectrum for each subject. All subjects completed these tests first in the lab and later online at home using their personal computers and headphones.

Results: Results from the clinical bracketing method showed that the average difference between lab and online was about 0.5 octave and no significant difference in final pitch between lab and online when analyzed at the

group level. Results from the similarity rating method demonstrated a high positive correlation (mean $r > 0.75$) between online and lab for most of the subjects ($n=11$).

Conclusions: Based on the results, it can be concluded that online testing is a possible approach for tinnitus measurement with results from online testing comparable to those from in-person services at both group level and individual level. This implies that individuals with tinnitus could be served without the constraint of time and locations. Also, the online testing using no-touch audiological care is helpful for keeping audiologists and patients safe during COVID-19 pandemic.

Category: Tinnitus

Poster #: 147

Somatic Maneuvers and their effect on Tinnitus

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Objectives: Tinnitus is the perception of sound in the absence of external auditory input. The most common factor associated with tinnitus is hearing loss. Up to 80% of tinnitus patients can modulate their tinnitus by movements of the head or neck - a phenomenon termed "somatic or somatosensory tinnitus (Levine, Abel; CRANIO, 2004)." Herein, we examine the relationships between hearing threshold, somatic tinnitus, and perceived tinnitus severity.

Design: Data from 207 participants was used for this analysis. Modulation assessments were performed either in-person in a standard audiological clinical sound booth, or remotely while participants were in a quiet room. Standard pure tone audiometry was performed, and the Tinnitus Functional Index (TFI; Meikle et al, 2012) questionnaire was utilized to assess reactions to tinnitus. To quantify somatic-induced changes, participants were instructed to report increases or decreases in tinnitus loudness on a 0-4 scale (0 = no change; 4 = greatest change) (Roberts reference/Levine reference). Modulation scores were grouped by cranial nerve (CN) innervation: CN III, IV, VI for eye maneuvers, CN V for jaw, CN VII for cheek maneuvers, CN XI and dorsal column spinal nerves for neck maneuvers, and CN XII for tongue maneuvers. CN XI and dorsal column spinal nerves are also separated by a subset of maneuvers: Passive, Active, and Active with Resistance.

Results: The mean number of modulations that altered tinnitus loudness per subject was 16.14 . Further, more than half of somatic maneuvers increased tinnitus loudness. Somatic maneuvers involving CN V, XI or spinal nerves were the most likely to alter tinnitus loudness (counts/proportions). For CN XI and spinal nerve maneuvers, Active with Resistance maneuvers consistently elicited a change in tinnitus loudness, while Active maneuvers elicited more increases than Passive movements. TFI scores positively correlated with the sum of effective modulations ($r=0.216$; $p=0.004$), suggesting that subjects with more effective modulations had more bothersome tinnitus. Moreover, pure tone average (PTA; 500Hz, 1kHz, 2kHz, 4kHz) and the sum of effective modulations were inversely correlated ($r=-0.118$; $p=0.011$).

Conclusions: The negative correlation between PTA and effective somatic maneuvers suggest that better hearing thresholds were associated with more effective somatic modulations. Furthermore, greater tinnitus severity was associated with an increased ability to modulate tinnitus with a somatic maneuver. Interestingly,

jaw and neck movements were associated with more effective modulations, supporting previous work showing that projections from these regions activate the cochlear nucleus neurons linked to tinnitus generation.

Category: Tinnitus

Poster #: 148

Multimorbid Military TBI, PTSD, and Tinnitus in a Veteran Cohort

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Objectives: Traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) are prevalent conditions among military Veterans and separately have been shown to be associated with tinnitus. It is unknown if the combined presence of TBI and PTSD are associated with a greater prevalence of tinnitus than what would be expected given either condition alone. Furthermore, we lack an understanding of the multimorbid presentation of TBI, PTSD, and tinnitus on functional outcomes. The objective of this study was to investigate independent and joint effects of TBI and PTSD on tinnitus in post-9/11 Veterans and to what extent their co-occurrence affects functioning among those with tinnitus.

Design: Participants enrolled in the Noise Outcomes in Servicemembers Epidemiology Study (n=597) completed a comprehensive hearing and tinnitus examination which included assessing military-related TBI history and PTSD screening. We examined cross-sectional associations between TBI, PTSD, and tinnitus and describe the functional outcomes among those presenting with all three conditions. Individual and joint effects of TBI history and positive screens for PTSD on the prevalence of tinnitus were investigated using logistic regression; potential interactions were examined on multiplicative and additive scales. Based on an a priori causal model, multivariable regression models were adjusted for demographics and military service characteristics.

Results: In our sample of Veterans, 26% (n=155) had a history of TBI, 37% (n=222) screened positive for PTSD, and 58% (n=349) had tinnitus. Independently, Veterans with TBI had 2.3-fold (95% CI: 1.2-4.4) higher odds of tinnitus and Veterans with PTSD had 2.1-fold (95% CI: 1.3-3.3) higher odds of tinnitus, compared to those with neither. Jointly, Veterans with both TBI and PTSD had 5.2-fold (95% CI: 2.7-10.3) greater odds of tinnitus compared to those with neither. The joint effect of TBI and PTSD on tinnitus prevalence is greater than the sum of the effects of each exposure when considered separately, suggesting a weak additive interaction. No statistically significant multiplicative interaction effect was observed between TBI and PTSD and prevalence of tinnitus. Finally, 46% of individuals with multimorbid TBI and PTSD reported their tinnitus as severe compared to only 13% of individuals with neither condition. Individuals with multimorbid TBI, PTSD, and tinnitus were also more likely to report needing frequent breaks while doing work, reducing the amount of time spent on work, and accomplishing less than they would have liked to compared to individuals with only tinnitus.

Conclusions: History of TBI and a positive screen for PTSD are independently associated with chronic tinnitus. There appears to be an additive interaction between TBI and PTSD on tinnitus prevalence, but further research is needed. The combined presence of TBI and PTSD may be associated with greater tinnitus severity, which is likely to affect functional outcomes. These preliminary findings suggest taking an interdisciplinary approach

involving audiologists and mental health providers is warranted to best meet the complex needs of Veterans with multimorbid military TBI, PTSD, and tinnitus.

Category: Tinnitus

Poster #: 149

Somatosensory Tinnitus: More Than a Feeling

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Objectives: Somatosensory tinnitus, a subtype of primary tinnitus, is characterized by changes in a patient's tinnitus (either pitch or loudness) associated with certain head and neck maneuvers. It is most prominently observed in patients with a history of trauma to the head, neck, or cervical spine, or a history of temporomandibular joint (TMJ) dysfunction, bruxism, or other underlying somatic disorders. Although clinical consensus does not exist on how to diagnose somatosensory tinnitus, promising advances have been made in the last 5 years. Specifically, expert recommendations have been published on inclusion/exclusion criteria to diagnose somatosensory tinnitus and various treatment approaches have been evaluated. Despite these advancements, research focused on somatosensory tinnitus still makes up only a minute fraction of publications pertaining to tinnitus over the past two decades. The purpose of this poster is to increase awareness about somatosensory tinnitus.

Design: A literature review was conducted surveying PubMed's virtual database to compile information published on somatosensory tinnitus, focusing on its dynamics, diagnosis, and treatment options. Two searches were conducted over the course of a month using the following criteria: (1) articles published from 2000 through 2020 that involved human subjects and had abstracts available; and (2) search terms included MeSH terms and keywords "tinnitus [MeSH]" and "(tinnitus [MeSH] AND (somatic OR somatosensory))."

Results: From 2000-2020, 5,622 articles were identified that included the search term "tinnitus [MeSH]" and, of those 5,622 articles, 170 included the term "somatic OR somatosensory tinnitus." Of these 170 articles, which amounts to 3% of the peer-reviewed articles mentioning "tinnitus" in this timeframe, only 50 highlighted somatosensory tinnitus as the primary focus of the article. The remaining 120 articles contained the search terms but did not go into detail about somatosensory tinnitus.

Conclusions: It has been more than 20 years since somatosensory tinnitus was first introduced into the peer-reviewed literature, yet many health care professionals are still unaware of its existence. Since the early 2000s, research focused specifically on somatosensory tinnitus has made up only around 3% of the peer-reviewed tinnitus literature. Articles addressing its prevalence estimate between 60-80% of tinnitus patients are able to modulate their tinnitus, and yet awareness in the audiologic community is minimal for such a highly prevalent condition. More research is needed to better understand all aspects of somatosensory tinnitus. Audiologists might consider including a few follow-up questions when evaluating tinnitus patients to screen for

somatosensory tinnitus, because when identified, an interprofessional approach is often needed to best meet the patient's needs.