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POSTER ABSTRACTS

Topic areas and poster numbers:

AUDITORY PROCESSING / LISTENING EFFORT

Category: Auditory Processing/Listening Effort

Poster #: 001

Inferring Daily-Life Listening Effort by Conditioning Heart Rate on Sound Exposure

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Objectives: This study explores the potential of physiological signals, such as heart rate, as non-invasive indicators for listening-related effort in daily life. When real-world physiological signals are conditioned on ambient sound exposure, they may reveal distinct patterns of arousal linked to listening-related activities.

Design: A novel hybrid study was conducted involving 22 hearing aid users with varying experience and age, all of whom had bilateral mild to severe hearing loss. The study consisted of a laboratory-based noise impact test followed by a 2-week field trial. In the lab, heart rate, heart rate variability, and skin conductance were recorded under different noise levels (0 vs. 6 dB SNR), loudness levels (55 vs. 63 dB Leq), and tasks ("rest", "listen", "read"). On each trial, speech (news clips) was presented frontally, and noise (ICRA natural sounds) was presented bilaterally and behind the participants. In the "rest" task, participants were asked to rest and clear their minds; in the "listen" task they were asked to focus on the speech; and in the "read" task they were asked to read a text (150-180 words) on a computer screen. Following each "listen" and "read" trial, participants had to answer five yes/no questions about the content of the speech or text. In the field trial, sound exposure was recorded every 20 seconds using participants' own hearing aids, along with continuous heart rate, skin conductance, and activity counts using Empatica E4 wearables. Mean heart rate was then computed for each percentile of the observed SPL and SNR for each participant.

Results: In the lab, heart rate was sensitive to different noise and loudness levels only when participants were asked to listen to the speech. In the field trial, heart rates were significantly associated with ambient SPL (positive association) and SNR (negative association). Importantly, changes in heart rate across lab conditions versus across percentiles of the sound-pressure levels and signal-to-noise ratios in the field correlated strongly and significantly only for the "listen" task, suggesting that variations in heart rate observed in the field were related to listening activities.

Conclusions: Heart rate in everyday life is associated with ambient sound-pressure levels and signal-to-noise ratios, and the underlying cause appears to be listening-related factors. It is speculated that changes in arousal result from changes in effort levels exerted for real-world conditions differing in listening difficulty.

Category: Auditory Processing/Listening Effort

Poster #: 002

The Effects of Mild TBI on Suprathreshold Auditory Processing

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Objectives: Individuals with a history of mild traumatic brain injury (mTBI) often report difficulties understanding speech in competition that are not well predicted by the pure-tone audiogram. Given that previous work has demonstrated relationships between suprathreshold auditory processing abilities and speech understanding in competition, the current study aimed to identify the effect of mTBI on suprathreshold auditory processing and to determine whether performance is related to variability in speech understanding in this patient population. It was predicted that participants with a history of mTBI would perform more poorly on each suprathreshold auditory processing task, including the measures of speech understanding in noise, and that performance among measures would be correlated. However, based on previous work, it was also predicted that there would be a substantial amount of variance unaccounted for, suggesting that additional factors such as cognitive processing abilities should be considered to better explain speech understanding deficits in those with mTBI.

Design: Participants included 62 individuals with (n=30) and without (n=32) a history of mTBI who ranged in age and hearing sensitivity. Participants completed behavioral tests in the Portable Automated Rapid Testing (PART) iPad app that assessed spectral, temporal, and spectrotemporal modulation detection as well as diotic and dichotic frequency modulation sensitivity. Speech understanding in competition was measured in a spatial release from masking task. Regression models were used to determine the effects of mTBI on performance on each measure after controlling for variability in age and hearing sensitivity and to identify how performance on these measures explains variability in speech understanding in competition in this clinical population.

Results: Results showed no significant differences in performance between those with and without a history of mTBI on any of the behavioral tasks. However, despite similar performance across participant groups, results indicate that the suprathreshold auditory processing measures were not predictive of speech understanding abilities in participants with mTBI. These findings are in contrast to previous work that has demonstrated relationships between suprathreshold auditory processing abilities and speech understanding in competition in individuals varying in age and hearing sensitivity, and suggests that additional factors unique to mTBI must be identified to explain variance in performance.

Conclusions: These results provide new information about the effects of mTBI on suprathreshold auditory processing and speech understanding in competition. This work will inform future studies that will examine additional factors, including cognitive performance, that likely influence speech understanding in this patient population. [R01DC018166]

Category: Auditory Processing/Listening Effort

Poster #: 003

Exploring the Interaction of Working Memory and Attention on Listening Effort

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Objectives: This study investigates how variations in working memory (WM) and attention demands during listening effort (LE) assessments contribute to inconsistencies in the literature. Utilizing different cognitive demand levels, the study aims to reveal age-related variations and offer insights for addressing LE in clinical and aging-populations with a reliable assessment tool. To achieve these objectives, the study is guided by the following specific aims:1)Investigate the impact of increased attentional demand on LE in young versus older-adults.2)Assess the influence of increased WM demand on LE in young versus older-adults.3)Explore the relationship between attention and WM for LE across the two age-groups.4)Determine the reliability of the method employed for measuring LE.

Design: Guided by a medium effect-size from pilot-data and existing literature on age group differences, an a priori analysis determined a sample-size of 30 normal-hearing participants, including young-adults (18-35 years) and older-adults (>50). Assessments included behavioral measures (WM and dichotic-digit scores), physiological measurements (pupillometry), and subjective ratings on the LE. The Word Auditory Recognition and Recall Measure (WARRM) assessed WM-capacity, which formed the reference point for low/high-demand set-sizes for WM.Data collection involved a Tobii-T60-XL-eye-tracker. Participants engaged in WM-only and attention-only conditions, with attention assessed through a dichotic digit paradigm, with demand manipulated by requiring participants to repeat digits heard in the right ear only (AttnD-low) or in both the right and left ears sequentially (AttnD-high). The WM-only condition involved two levels of WM demand (WMD-low and WMD-high) at n-1 and n+1, respectively. Participants listened to n+1 and n-1 words and were subsequently asked to recall them after a retention period. Additionally, the study explored various WM and attention combinations in low and high-demand scenarios, with continuous pupil-data gathered across 20 trials per condition. Here, WM is the initial task, followed by a retention interval during which participants performed a dichotic test as a distractor task. Subsequently, participants were asked to recall the words heard during the initial part of the trial. It encompassed WMD-low + AttnD-low, WMD-low + AttnD-high, WMD-high + AttnD-low, and WMD-high + AttnD-high combinations. Test-retest reliability was assessed with a 20% subject sample over a three-to-six-week gap.Repeated Measures ANOVA analyzed peak-pupil dilation (PPD) data, examining main-effects and interactions for WM and Attention, with high-and low-demand levels. Age, WM-capacity, and attention-alone conditions were covariates, and Intraclass-Correlation-Coefficient (ICC) values determined test-retest reliability.

Results: Pilot-data from six participants indicated higher PPD in the high-demand condition (Cohen's d = .54) with strong ICC values (0.877-0.751), supporting test-retest reliability.Expected Results:1)Elevated attentional and WM demand will increase pupil-dilations, especially in older adults.2)The interaction between attention and WM will enhance pupil-dilation, varying by age.3)The LE measure will exhibit good test-retest reliability.

Conclusions: This study addresses literature gaps by exploring the impact of WM/attention demands on LE assessments. By varying cognitive demands, the study fills gaps in understanding whether differences in demand contribute to observed inconsistencies, aiming to provide insights for assessing LE in clinical and aging-populations marked by hearing-impairment and cognitive -decline.

Category: Auditory Processing/Listening Effort

Poster #: 004

Working Memory in Age-Related Hearing Loss: An fNIRS Study

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Objectives: Age-related hearing loss (ARHL) significantly increases listening effort by taxing working memory (WM) resources. These WM resources are critical components for speech perception in noise. This preliminary study explores the behavioral and neurophysiological results of speech perception in noise and WM in older adults with ARHL immediately after being fitted for hearing aids.

Design: Twelve participants (N=12, Mean Age=80.3) with bilateral sensorineural hearing loss and a speech frequency pure tone average exceeding 40 dB HL have been enrolled in an on-going two-group, parallel, randomized, wait-list controlled trial. All participants scored 26 or higher on the Montreal Cognitive Assessment, indicating normal cognitive function, but none had worn hearing aids prior to enrollment. During baseline, participants were fit with hearing aids (Oticon More 1 and Signia Pure Charge and Go (C&G) 7AX), completed the Quick Speech in Noise (SIN) task and a continuous auditory N-back task with 0-back, 1-back, and 2-back conditions, each with 32 trials and a three-second response window. fNIRS measurements were captured with the Hitachi ETG-4000, targeting the frontal and temporal lobes.

Results: The Quick SIN scores had a strong positive correlation with the accuracy of the N-back task and a negative correlation with the N-back response time. As expected, task accuracy decreased with increasing difficulty; the 0-back condition showed the highest accuracy, while the 2-back condition showed the lowest accuracy. Similarly, response times lengthened as task difficulty increased, with the quickest responses observed in the 0-back condition and the slowest in the 2-back condition. During the 2-back task, there was a significant increase in oxygenated blood flow in multiple channels over the left temporal lobe suggesting heightened neural activity in comparison to the 0-back and 1-back tasks. Conversely, the frontal lobe exhibited minimal increases suggesting an atypical pattern of activation during a working memory task.

Conclusions: Immediately after being fitted with hearing aids, elderly adults with ARHL present interrelated difficulties with speech perception, attention, and working memory. Our early findings reveal neurophysiological bases of these difficulties. Typically, increased neural activity during a 2-back task is seen in the prefrontal cortex of adults; however, our findings of increased neural activity in the temporal lobe in conjunction with minimal neural activity in the frontal lobe suggest an atypical neural compensatory mechanism in elderly hearing-impaired. This shift implies that, in the context of ARHL, cognitive resources may be reallocated from frontal problem-solving regions to auditory processing cognitive strategies in the temporal regions. Such reorganization might indicate a potential adaptive response of the brain to compensate for hearing difficulties associated with aging at the expense of storage and manipulation in WM. Our findings highlight the significant role of WM in speech perception

for individuals with ARHL and illustrate the brain's adaptability in response to sensory deficits. Understanding these compensatory mechanisms could help support cognitive functioning in the aging population with hearing impairments.

Category: Auditory Processing/Listening Effort

Poster #: 005

Children's Real-Time Spoken Word Recognition while Listening in Two-Talker Speech

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Objectives: To comprehend speech, children must efficiently process spoken words and access word meaning in real time. This dynamic process includes lexical access (word form recognition) and semantic activation (word meaning recognition). School-age children must comprehend speech in the presence of other talkers, as this is a common classroom listening situation. It is unclear how competing speech interferes with children's real-time spoken word recognition efficiency. The objective of this study was to characterize the effects of low- and high-intensity competing two-talker speech on the time course of real-time lexical access and semantic activation in children with typical hearing. I hypothesized that both low- and high-intensity two-talker speech would delay children's lexical access and reduce semantic activation, even when word recognition accuracy remained high.

Design: Twenty children ages 10-12 with typical hearing are expected to participate. All children were native English speakers without language or cognitive delays. The experimental task used eye-tracking in the visual world paradigm (VWP). On each trial, four images appeared on a computer screen. Participants heard the target word at 64 dBA, then clicked the corresponding image. Gaze was recorded throughout the task. Half the trials included a cohort competitor, which shared initial phonology with the target (e.g., puppy, puppet). The other half included a semantic competitor, which shared semantic features with the target (e.g., helmet, armor). Two unrelated items served as baselines for looking behavior. Fixations to each item type were averaged across trials and used as an index of lexical activation; fixations were only analyzed for accurate trials.Each child completed three VWP conditions: one in quiet, and two with competing two-talker speech. In the Hard SNR condition, the two-talker speech was presented at an individually determined level expected to result in 70% accuracy. In the Easy SNR condition, the two-talker speech was reduced 10 dB from the Hard SNR condition. Each condition included 232 trials. Condition order was counterbalanced.

Results: Data collection is ongoing through 2023; preliminary analyses include eight children. Mean accuracy was 99.7% in Quiet, 95.5% in Easy SNR, and 82.8% in Hard SNR. When no phonological competitors were present, accuracy was equivalent in the Quiet (M=99.8%) and Easy SNR (M=99.2%) conditions ($p=.14$).Children were 38 and 105 ms slower to look to the target in the Easy and Hard SNR conditions, respectively, relative to Quiet ($p's<.03$). These differences remain significant even when no phonological competitors were on the screen. After accounting for unrelated item fixations, cohort fixations were reduced in the Hard SNR condition ($p=.05$), but not the Easy SNR condition ($p=.56$), relative to Quiet. Semantic competitor fixations were reduced in the Easy SNR condition relative to the Hard SNR condition ($p<.05$), though semantic fixations in Quiet did not differ from those in either SNR conditions ($p>.2$).

Conclusions: Even when word recognition accuracy is unaffected, low-intensity competing speech slows children's lexical access speed. Competing speech may also reduce children's real-time semantic activation. In noisy settings like a classroom, even low-intensity competing speech may impair children's ability to process and comprehend speech.

Category: Auditory Processing/Listening Effort

Poster #: 006

Auditory Symptom Profiles in Patients with Mild Traumatic Brain Injury

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Objectives: Mild traumatic brain injury (mTBI) is characterized by a wide range of symptoms that vary across patients. This heterogeneity poses a challenge to clinicians who need to identify specific clinical assessment and treatment protocols for individual patients. Recent work in this area has focused on classifying common mTBI symptoms into subtypes in an effort to address the patient's predominant clinical presentation and aid in clinical care. Clinical consensus exists for five symptom subtypes (cognitive, ocular-motor, headache/migraine, vestibular, anxiety/mood) and two associated conditions (sleep disturbance, cervical strain). However, despite growing evidence that auditory difficulties are common in individuals with a history of mTBI, these symptoms are not often included in concussion assessments nor as a possible separate symptom subtype or associated condition. The aims of this project were to estimate the prevalence and severity of self-reported auditory symptoms following mTBI and explore relationships between auditory symptoms and other mTBI symptom subtypes.

Design: This work was completed as part of a multi-site study aimed at developing and assessing a new self-reported symptom rating scale called the Concussion Symptom Subtype Inventory (CSSI). The CSSI includes self-report items that fall within each symptom subtype and associated condition listed above and requires individuals to rate their symptom severity on a scale of 0-6 at the current time point as well as estimate their symptom severity before their injury. A modified version analyzed as part of this work included additional items about auditory symptoms related to tinnitus, sound/noise sensitivity, and speech understanding. Analysis was completed on data from 130 individuals who completed the CSSI through Oregon Health & Science University's (OHSU) Sports Concussion Clinic or through participation in various OHSU research studies that have enrolled participants with a history of mTBI.

Results: Analysis revealed that a substantial proportion of participants self-reported an increase in severity of at least one auditory symptom following their mTBI. Further analyses provided novel information about relationships among CSSI items and patterns of auditory symptoms across individuals.

Conclusions: This work provides important information about auditory difficulties commonly occurring after mTBI and will be used to strengthen support of including an auditory symptom subtype. These

findings will help drive future research that aims to better understand, measure, and manage auditory symptoms associated with mTBI. Future work in this area will also assist to establish the validity of the CSSI for the clinical assessment of mTBI symptoms. [R01 DC 018166, VA RR&D RX003941]

Category: Auditory Processing/Listening Effort

Poster #: 007

Auditory Working Memory and Dichotic Word Recognition in Adults

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Objectives: The purpose of this study was to investigate the influence of auditory working memory on dichotic word recognition, the dichotic ear advantage, and self-perceived listening difficulty in young and older adults. Researchers predicted performance on dichotic stimuli would reveal a right ear advantage and adults with poorer auditory working memory would have poorer performance when dichotic stimuli difficulty is increased, especially in the left ear.

Design: Two groups of right-handed adults participated: 15 young adults (18-35 years) and 15 older adults (60-89 years). Pure-tone thresholds were ≤20 dB HL from 250-8000 Hz for the young adults. Older adults had varying degrees of sensorineural hearing loss. Perception of listening difficulty was measured using the Adult Auditory Processing Scale (AAPS). Dichotic word recognition (DWR) was measured in a free-recall condition using NU-6 words categorized by lexical difficulty. All dichotic words were lexically categorized as easy or hard based on neighborhood frequency and density. Auditory working memory was measured using the Word Auditory Recognition and Recall Measure (WARRM).

Results: Results revealed that auditory working memory was significantly ($p < .05$) correlated with DWR ($r = .396$) and AAPS scores ($r = -.515$), suggesting that individuals with poorer auditory working memory exhibited poorer dichotic listening ability and greater perceived listening difficulty. The older adult group drove the relationships, as age was significantly correlated with all variables. DWR results revealed a significant effect of lexical difficulty, lexically hard words being more difficult to recognize than lexically easy words for both young and older adults. Dichotic ear advantages for lexically mixed word pairs (easy-hard) varied by group. Young adults exhibited better performance for easy versus hard words, regardless of the presentation ear. Therefore, the ear advantage was consistent with the ear presented the easy word. In contrast, older adults exhibited better performance for words presented to the right ear compared to the left, regardless of lexical difficulty. Significant correlations were identified between left ear performance and auditory working memory in the hard-hard condition ($r = .437$) and the right hard-left easy condition ($r = .362$).

Conclusions: Findings suggest poorer auditory working memory is related to DWR performance among older adults. Self-perception of listening difficulty was consistent with these findings. Specifically, listeners with poorer auditory working memory perceived greater listening difficulty across listening tasks. As expected, lexical difficulty affected DWR performance, with listeners performing poorer on lexically hard versus lexically easy words. Older adults were unable to take advantage of lexically easy words presented to the left ear, resulting in a persistent right ear advantage for all word combinations.

Further identified relationships between left ear performance and auditory working memory may suggest that when there are greater processing demands for stimuli presented to the right ear, the preferential auditory pathway, left ear performance suffers. Taken together, the present findings suggest that auditory working memory plays an important role in the binaural integration, especially for older adults. Finally, clinical measurements of auditory working memory may provide useful insights related to listening in complex conditions and self-perception of listening ability.

Category: Auditory Processing/Listening Effort

Poster #: 008

Cortical Influence on Auditory Periphery: A Transcranial Magnetic Stimulation Study

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Objectives: The brain exerts its control over the ear. How it does this and what implications this control has on human hearing is not well understood. Here we investigate how corticofugal feedback systems allow the auditory cortex to influence how the ear works. A better understanding of this feedback control can help us (1) devise diagnostic tools that can detect hearing loss early, and (2) aid in the development of therapeutics for auditory disorders such as tinnitus. We hypothesize that inhibition of cortical activity will affect auditory efferent functioning via the medial olivocochlear reflex. We predict that cortical inhibition using repetitive transcranial magnetic stimulation will induce measurable changes at the periphery in the form of an increase in the magnitude and faster kinetics of the medial olivocochlear reflex and the subsequent inhibition of click-evoked otoacoustic emissions. This prediction is rooted in our understanding of medial olivocochlear reflex physiology, which suggests that the auditory cortex plays a modulatory role in regulating the reflex pathway.

Design: Twenty-two normal-hearing young adults with no personal or familial history of neurological disorders participated in this study (20 females, 2 males; age range: 18-35, mean age: 23). We employed low-frequency repetitive transcranial magnetic stimulation bilaterally to induce transient cortical inhibition localized to the auditory cortex. Click-evoked otoacoustic emissions were used to observe the effects of the auditory cortex on outer hair cell electromotility, mediated via a brainstem feedback system, and electroencephalography was used to observe changes in cortical excitability. As a control condition, transcranial magnetic stimulation was also applied to the vertex where we do not expect it to cause any observable effects at the periphery.

Results: Overall, although most participants demonstrated reliable efferent activity, no significant changes were observed in click-evoked otoacoustic emissions, or electroencephalography following bilateral temporal stimulation. Our results suggest that the application of transcranial magnetic stimulation in the auditory cortex may not be as effective as previously reported. Used in this way, transcranial magnetic stimulation is unique, and as such, is not yet underpinned by sufficient literature to obtain consistent and valid results. Hence, this study adds to the growing body of knowledge on

transcranial magnetic stimulation applications, with particular relevance to studies investigating conditions of the auditory system. While the extent of our findings is constrained by the novelty of using transcranial magnetic stimulation in the auditory cortex, this approach offers fresh insights into the limitations of this technique when applied to the auditory cortex.

Conclusions: In conclusion, this study is original in its paradigm and establishes that transcranial magnetic stimulation protocols may not be as generalizable as previously thought, as well as highlighting the overall scarcity of existing research in this area. To gain a deeper understanding of the implications revealed in this study and to provide additional context to this argument, a pressing need exists for further exploration aimed at standardizing and refining protocols for using transcranial magnetic stimulation in the auditory cortex.

Category: Auditory Processing/Listening Effort

Poster #: 009

Training Spatial Listening Ability in School-Age Children with Listening Difficulty

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Objectives: To measure the efficacy of the Listening in Spatialized Noise (LiSN & Learn) training program (SoundStorm) in improving speech perception in noise ability in children with listening difficulty.

Design: The study was completed using a pre-post intervention design. Qualifying participants included 20 children (between 8 and 11 years of age) who passed hearing and nonverbal IQ screening. The children were reported to have listening difficulties (based on parental report on the Evaluation of Children's Listening and Processing Skills questionnaire). In addition, their responses to complex Auditory Brainstem Response measurements, obtained with a 40ms /da/ stimulus, displayed latencies exceeding one standard deviation above the mean. Pre- and post-treatment measures included the Listening in Spatialized Noise diagnostic test and the Bamford-Kowal-Bench (BKB) Speech in Noise test. Children were randomly placed into either a control or a treatment group. In the control group, out of the 10 enrolled children, 2 dropped out before study completion. We successfully collected data from the 8 controls who completed the study. Auditory training was facilitated using the SoundStorm application, designed to enhance spatial auditory skills in school-aged children with Spatial Processing Disorder. This application features four interactive games played on an iPad, delivering a three-dimensional sound experience via headphones. Children engaged with the program for 15 minutes a day, five days a week for 12 weeks. The core activity required children to discern target sentences amidst competing speech. The app maintains a constant frontal position for target speech, while the background noise varies in its perceived origin-directly ahead at 0° azimuth or from the sides at ±90° azimuth. Additionally, the pitch of the background noise is manipulated to either match or contrast with that of the target speech, leading to two distinct scenarios: the "low cue" condition, where pitch and spatial positioning of target and competing speech are identical, and the "high cue" condition, where both pitch and spatial cues differ. Sentences are relayed from the frontal 0° azimuth and interfering narratives from the ±90° azimuth. The

task for children is to choose an image corresponding to a word from the target sentence. The difficulty level, dictated by the signal-to-noise ratio (SNR), is adaptively adjusted using a weighted up-down method.

Results: The treatment group displayed a 75% improvement in LiSN scores with a mean enhancement of 0.87 dB SNR, and a 62.5% improvement rate in BKB scores with a mean increase of 1.02 dB SNR. However, there was a noted decrease in performance for some participants, with 25% showing a worsening in LiSN scores (mean decrease of -1.70 dB SNR) and 37.5% in BKB scores (mean decrease of -1.63 dB SNR). The control group results were somewhat parallel, with 75% showing improved LiSN scores (mean increase of 1.09 dB SNR) and 50% improved BKB scores (mean increase of 0.69 dB SNR). These patterns of variability suggest influences beyond the intervention itself. Notably, the changes in mean scores did not achieve statistical significance, underscoring the need for cautious interpretation of the data.

Conclusions: Although there is an observable trend towards improvement in listening in noise abilities post-intervention, the concurrent improvements seen in the control group necessitate further investigation into the specific effects of the intervention versus natural developmental progression or other extraneous factors. The absence of statistically significant results indicates a possible requirement for a larger sample size to definitively ascertain the program's effectiveness. Additionally, the mixed response to the intervention calls for consideration of individualized auditory therapy approaches. Future studies should aim to unravel the factors that contribute to response variability and examine the potential for tailored treatment protocols. The current study highlights the intricate nature of evaluating auditory intervention outcomes and the importance of conducting rigorous, sufficiently powered trials to inform evidence-based clinical practices.

COCHLEAR IMPLANTS

Category: Cochlear Implants

Poster #: 010

Combined Sound Localization and Speech-in-Noise Task in Bilateral Cochlear Implants

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Objectives: Binaural hearing is essential for localizing sound and understanding speech in noise. Due to their potential for restoration of binaural hearing, bilateral cochlear implants are a desirable solution for bilateral hearing loss. While it is well established that bilateral cochlear implantation is superior to unilateral implantation for restoring sound localization and speech comprehension in noise for patients

with severe-to-profound hearing loss, it remains the case that bilateral cochlear implantation is inferior to normal hearing when it comes to accuracy of localization and speech-in-noise understanding, without a clear source for the majority of performance outcome variability. To our knowledge, there has not been a granular analysis of the compensatory mechanisms for optimizing sound localization and speech-in-noise performance in patients with bilateral cochlear implants. To gain insight into these adaptive behaviors, we used a novel testing paradigm that simultaneously tests speech-in-noise perception and localization while tracking head movements in a 360o-configuration and real-time ear-level acoustic cues to monitor ear-level signal-to-noise optimization. The objective of this study was to quantitatively and objectively study the listening behavior of individuals in this population to gain a deeper understanding of the adaptive behaviors used to improve performance on tasks of binaural hearing.

Design: Subjects with normal hearing or bilateral cochlear implants were tested in a dark, semi-anechoic chamber equipped with a 24-speaker array equally-spaced in a 360-degree configuration. On each trial, an orienting stimulus followed by a Harvard IEEE sentence was presented from one of 12 randomly selected target speakers in a background of pink noise at seven different signal-to-noise ratio levels from -10 dB to +10 dB. Participants were instructed to behave naturally and encouraged to move their heads freely to localize sound and their task was to repeat the sentences and report sound source location. Head movement was continuously tracked using an electromagnetic head-p system, and probe-tube in-ear microphones captured real-time, ear-level acoustic input to each ear.

Results: Data will be presented comparing head movement patterns (movement delay in ms, absolute displacement in degrees, and response time in ms), localization accuracy (in root-mean-square error and linear best-fit characteristics across targets), and speech-in-noise performance (percent correct as a function of signal-to-noise ratio) between subject groups. Furthermore, we will quantify ear-specific acoustic input, including ear-level signal-to-noise ratios.

Conclusions: Our study provides a detailed account of sound localization and speech-in-noise perception in bilateral cochlear implant recipients, including unique compensatory listening behaviors and acoustic cue adjustments. This study uncovers some of the subtle strategies and challenges faced by bilateral cochlear implant users in localizing sound and comprehending speech in noise. Data presented here will inform the ultimate goal of computing metrics of binaural hearing to better clinically characterize binaural listening impairment and more accurately assess outcome benefit for bilateral cochlear implantation.

Category: Cochlear Implants

Poster #: 011

Humanoid Robot-Assisted Psychophysics Testing of Cochlear Implanted Children

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Objectives: Assessment of hearing abilities of cochlear-implanted (CI) children often requires repetitive psychophysical tests, where participant engagement can become an issue. Vocal emotion perception presents a good example of this; i.e., it is a challenge for CI children, but needs to be evaluated well as emotion perception is important for general development. Human-robot interaction (HRI) has been proposed in literature as a tool to provide an engaging experience during repetitive tasks, perhaps linked to the novelty effect of interacting with a robot. We investigated the use of a humanoid NAO robot as an alternative interactive interface to psychophysics tests. For this purpose, we used a vocal emotion recognition (EmoHI) test, originally designed to be conducted via a computer.

Design: All participants were attendees of a summer camp for Spanish CI children. Forty children were tested, but four were excluded due to missing audio recordings of the experiment. The data of the remaining 36 CI children (aged 10-17; 15.01 ± 2.01 years) were included in the analyses. All children reported having used cochlear implants for at least one year before the study. The EmoHI test consists of 36 trials of pseudospeech productions from four speakers expressing three core emotions (happy, angry and sad). The participants took the EmoHI test twice, one using the game-like interface, implemented on the computer, and another using the NAO, in random order. Test setups were similar between interfaces, except the response logging when using the robot was done by a human supervisor manually. After finishing each of the EmoHI tests, children were presented with a questionnaire to evaluate their perception of the corresponding interface.

Results: Overall, the CI children's scores of this study were in line with previously reported results, showing difficulty in vocal emotion recognition across the tested age range. Preliminary test results in percent correct and d' (sensitivity index per emotion) across participants with the NAO were similar to those obtained with the computer. On average, children took one minute longer to complete the test when using the NAO than when using the computer. Results of the questionnaires indicate that even though the NAO does not offer a performance improvement, children had a higher preference for the NAO than the computer.

Conclusions: While the EmoHI test is difficult, as shown by childrens' relatively low test scores, all children were able to finish the test on both interfaces. The similarity in EmoHI test results in both percent correct and d' between the computer and the robot, supports NAO's ability as a test interface with CI children to present auditory stimuli and collect auditory perception data. The results produced by the NAO seemed not to be negatively affected by the longer test duration, and also, despite the longer test duration, HRI assessment indicated higher preference for NAO by children. All results combined, while computer assessment remains the gold standard for hearing tests, the present results indicate other interfaces could also be beneficial, and also enjoyable, for psychophysical testing child populations with hearing loss.

Category: Cochlear Implants

Poster #: 012

WITHDRAWN

Category: Cochlear Implants

Poster #: 013

Examining Vocal Auditory Feedback Control in Simulated Cochlear Implant Speech

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Objectives: While the primary goal of cochlear implant (CI) is to enhance the overall communication abilities of the recipients, the current evaluation of CI outcomes has predominantly concentrated on the auditory perceptual capacities. However, successful spoken communication necessitates not only efficient auditory perception but also precise speech production. The importance of auditory feedback in the online monitoring and regulation of speech has received little attention in improvement of spoken communication in CI patients. Auditory feedback is partially impaired in listeners with CIs due to the limited spectral resolution as imposed by the small number of frequency processing channels and the suboptimal interaction of current between CI electrodes. It is yet unknown how the limited spectral and channel interaction properties impact vocal sensorimotor integration and control in CI listeners. We have developed a novel experimental paradigm that integrates a simulated cochlear-implant processing into the altered auditory feedback (AAF) paradigm to examine the effects of limited spectral resolution in CI users on voice motor control.

Design: The experiment was conducted in a sound-attenuated booth in which the subjects' vocal responses to real-time pitch-shifted auditory feedback were measured during speech vowel vocalizations. Subjects were instructed to maintain their steady speech vowel vocalization for 2-3 s while a brief (200 ms) pitch-shift stimulus was randomly delivered to alter auditory feedback in either upward (+100 cents, 1 semitone) or downward (-100 cents) direction. During each trial, subjects received the normal or cochlear-implant simulated version of their vocalization feedback in a randomized order. The CI-simulated speech was created using a noise-vocoder with 4, 8, 12, or 16 spectral channels. Vocal productions were recorded for a total of 100 trials per condition (50 trials per pitch-shift stimulus direction). Data were analyzed to extract the behavioral measure of speech compensation responses to AAF pitch-shift stimuli. First, the pitch frequency of the recorded speech signals was extracted in Praat and then exported to a custom-made MATLAB code for further processing. The extracted pitch frequencies were segmented into epochs ranging from -100 ms before to 500 ms after the onset of pitch-shift stimuli. Pitch frequencies were then converted from Hertz to the Cents scale and normalized to pre-stimulus baseline to calculate the magnitude of vocal compensation responses. The extracted pitch contours were then averaged separately for each individual subject across all trials for both the upward and downward pitch-shift directions and the number of spectral channels. The individual pitch contours were averaged across all subjects to obtain the grand-average profile of the vocal compensation responses for each condition in response to auditory feedback alterations.

Results: We found that compensatory vocal responses to pitch-shift stimuli were significantly diminished in simulated cochlear implant compared to normal auditory feedback, with the strongest effect observed with 4 spectral channels. These preliminary results suggest that listeners with cochlear implants experience impaired voice control due to limited access to fine-grained spectral information in their speech auditory feedback.

Conclusions: Our preliminary results provide new insights for the development of targeted interventions towards improving sensorimotor integration mechanisms in listeners with CIs.

Category: Cochlear Implants

Poster #: 014

Binaural Fusion for Normal Hearing Listeners and Cochlear Implant Users

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Objectives: Decreasing the interaural correlation of the envelope of a signal decreases binaural fusion (the percept of a single auditory image when signals are delivered to both ears) for both normal hearing (NH) listeners and individuals with cochlear implants (CI). However, these two groups differ in their ability to detect changes in interaural correlation, with individuals with CIs being less sensitive to changes in interaural correlation. The goal of this study was to compare binaural fusion for different interaural correlations for NH listeners and individuals with CIs.

Design: Five NH listeners and eight individuals with CIs were tested with stimuli containing a range of normalized envelope interaural correlations ranging from 0.4 to 1.0. The stimuli were presented over headphones for the NH listeners and through direct stimulation (i.e., circumventing the processor) for the listeners with CIs. Participants completed a binaural fusion task, where they manipulated ovals superimposed on an image of a head to indicate the number and spatial extent of the perceived auditory image(s).

Results: For NH listeners, the preliminary results suggest that stimuli no longer fused once the signal had an interaural correlation of 0.85 or below. In contrast, for the individuals with CIs, the interaural correlation needed to decrease to 0.75 or below for the signal to no longer be fused.

Conclusions: The results suggest that, for individuals with CIs, signals are perceived as effectively having increased interaural correlation compared to NH listeners (i.e. signals need to be more decorrelated to prevent fusion for individuals with CIs).

Category: Cochlear Implants

Poster #: 015

Hearing History May Influence the Music-Remixing Benefit in Electrical Hearing

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Objectives: Previous studies demonstrated that boosting vocals, drums, and beats while attenuating spectrally complex instruments enhanced the musical enjoyment for post-lingually deaf cochlear implant (CI) users, although the optimal degree of level adjustment for each musical source varied across subjects and studies. The benefit from remixing music may be influenced by the individual's hearing history. This study explores the divergence in preference for remixed music with different relative levels of different musical sources between pre-lingually deaf, early-implanted and post-lingually deaf, late-implanted CI users. We hypothesize that due to the lack of acoustic hearing experience, pre-lingually deaf, early-implanted CI users may have an overall higher level of music enjoyment, and prefer less attenuation of spectrally complex instruments than post-lingually deaf, late-implanted CI users.

Design: Our plan is to test 10 post-lingually deaf, late-implanted and 10 pre-lingually deaf, early-implanted CI users. Fifteen songs were selected from the top 100 most streamed songs on Spotify. The Demucs musical source separation model was employed to separate drums, bass, and vocals from the other musical instruments in each song. A ten-second segment with significant energy of all sources was extracted from each song. Based on previous studies, six different remixed versions were created: the original version (V1), two versions with a 6- or 12-dB reduction in bass, drums, and other instruments (V2 and V3, respectively), a version with a 3-dB reduction in bass and drums and a 12-dB reduction in other instruments (V4), and two versions with a 6- or 12-dB reduction in vocals (V5 and V6, respectively). Participants rated their appreciation of each remixed song clip using the Multi Stimulus Test with Hidden Reference and Anchor. Furthermore, the Goldsmiths Musical Sophistication Index was used to measure participants' musical experiences and their relationship with music.

Results: Preliminary data from 4 post-lingually deaf, late-implanted and 2 pre-lingually deaf, early-implanted CI users showed that the two groups had different patterns of appreciation for different remixed versions of the music clips. Pre-lingual CI users preferred the original version (V1) and the version with a 6-dB attenuation of all instruments (V2) over the other remixed versions, while post-lingual CI users preferred the version with a 12-dB attenuation of all instruments (V3). The differences in preference rating among the various remixed versions were greater in pre-lingual CI users than in post-lingual CI users. Additionally, pre-lingual CI users found the presented songs more familiar, rated the vocals more pleasant, and had generally higher musical sophistication scores than post-lingual CI users.

Conclusions: Data collection is still ongoing. The preliminary data suggest that hearing history may influence the appreciation of re-mixed music. For CI users who have not experienced music in acoustic hearing prior to implantation, songs with little or no attenuation of musical instruments may be preferred. The results of this study will increase our understanding of the factors contributing to music enjoyment with CIs and guide the development of customized music enhancement strategies for CI users based on their unique hearing backgrounds.

Category: Cochlear Implants

Poster #: 016

Piano Training Improves Speech-on-Speech Perception in Cochlear Implant Users

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Objectives: Speech-on-speech perception is challenging for cochlear implant (CI) users, but the large variability seen in scores implies that the implant may to some degree provide speech cues for the task, even if they are degraded. Therefore, training may help CI users to more efficiently make use of these degraded cues. Previous studies indicated a musician advantage for speech-on-speech perception, and benefits from music therapy, from active involvement and social interactions around music activities. Based on this literature, we investigated a newly developed music-based training, Guided Audiomotor Exploration (GAME), as a potential training tool for CI users. GAME is an alternative approach to piano instruction, promotes audiomotor integration in a motivating musical and social setting, uses the layout of the keyboard to acquire implicit knowledge of music, and allows pupils to extemporize their own music and realize their musical intentions without first having to overcome the obstacle of learning to read music.

Design: Twenty-four CI participants were (pseudo-)randomly assigned to one of the three groups: the GAME training (n=8, ages=58-74, mean=65.38 , stdev=5.83), Minecraft training (n=7, ages=28-82, mean=59.57, stdev=17.82), and no training (n=9, ages=21-80, mean=58.11, stdev=19.81). For both GAME and Minecraft groups, eighteen weekly lessons of 45 minutes each were completed within approximately six months. For GAME, piano teachers were trained to provide piano lessons in a specific format. For Minecraft, lessons were similar to the piano lessons, involving social interaction with a teacher and the motor component, but lacking the complex audio feedback involved in music making. The primary outcome was a speech-on-speech task based on the coordinate response measure, identifying a color and number in a sentence presented simultaneously with another speech stream from the same talker, with the same or altered voice parameters. Participants were tested before (zero months), halfway (three months), after the lessons (six months), and at a three month follow-up (nine months). The no-training group followed the same testing schedule. The current analysis pertains to before and after test points (zero and six months) for all three groups.

Results: The results, in line with previous studies, showed a large variability for percent correct scores across individual implant users. Despite this variability, some training effects were observed. Compared to no-training, GAME training had a significant positive effect on speech-on-speech perception. In contrast, the Minecraft training showed some small improvement, but this was not significantly different from either the no-training group or the GAME group.

Conclusions: These results indicate that learning a musical instrument could be beneficial for CI recipients' speech-on-speech perception. Especially the GAME method components of focusing on finger movements over note-reading, and extemporization of new note combinations, may foster audiomotor

integration and stimulate transfer effects to the speech domain. Moreover, the fact that some improvement was found in the Minecraft group is an encouraging sign that less resource-intensive activities such as video games, which contain an audiomotor component, can still benefit speech-on-speech perception.

Category: Cochlear Implants

Poster #: 017

Cochlear Implantation Evaluation Referrals Based on Patient English Proficiency and Socioeconomic Status

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Objectives: According to current research, there are socioeconomic and racial disparities in access to healthcare at large, including the field of audiology. Literature suggests that this is also true for cochlear implant services in the United States. The purpose of this study is to determine if there is a difference in referral rates for cochlear implant candidacy evaluations influenced by patient language proficiency level and socioeconomic status in a large health system.

Design: A retrospective chart review was conducted using audiometric data from 2015 to 2018 of adult patients at Henry Ford Health who qualified for a cochlear implant evaluation using the "60/60" referral guideline, meaning patients scored 60% or less on unaided word recognition tests and had a pure tone average of 60 dB or poorer. The data was further stratified into four categories: high English language proficiency level, limited English language proficiency level, high socioeconomic status, and low socioeconomic status. Comparisons were made for referral rates across all groups.

Results: Results show that although referrals for cochlear implant candidacy evaluations were equivalent across English language proficiency levels and socioeconomic status groups, follow through of scheduling and completion of the cochlear implant evaluations was significantly lower in the limited English language proficiency and low socioeconomic status groups.

Conclusions: Findings from this study are imperative to improving access to cochlear implant care for all populations and future research on how to improve follow through after recommendations for a cochlear implant are made is necessary.

Category: Cochlear Implants

Poster #: 018

Effects of Manipulating Channel Interaction on Music Perception

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Objectives: Cochlear implant (CI) users often face difficulties encoding spectral information, which negatively impacts their ability to perceive music (i.e., pitch, melody, and timbre). One of the biggest contributors to these difficulties is channel interaction, but the relationship between music tasks and channel interaction is not clearly defined. Spectral blurring is a method for measuring channel interaction in CI users by manipulating the excitation patterns of stimulation. Studies have shown a clear, inverse relationship between channel interaction and speech recognition, but the relationship between channel interaction and music perception is untested. Image-guided electrode selection (IGES) is a CT-based approach that identifies and deactivates electrodes causing extensive channel interaction. IGES has shown benefits for speech recognition, but the impact of IGES on music perception is unexplored. Therefore, the current study has two objectives. Objective 1 will characterize the effects of channel interaction on music perception using spectral blurring, hypothesizing that performance would decline as the amount of spectral blurring increases. Objective 2 will measure the degree of IGES benefit on music perception tasks, hypothesizing that performance will improve if channel interaction is reduced.

Design: Ten (anticipated N = 12) adults with at least one MED-EL CI participated. Electrode placement information was calculated from post-insertion CT imaging. Performance was compared between six conditions, 1) baseline (no blurring), 2) all blurred, 3) apical blurred, 4) middle blurred, 5) basal blurred, and 6) IGES. Music perception tasks included pure tone frequency discrimination and tone in noise discrimination using four base frequencies (196 Hz, 262 Hz, 1176 Hz, and 3136 Hz), as well as an adaptive melodic contour identification (MCI) task using three base frequencies (263 Hz, 1176 Hz, and 3136 Hz).

Results: For frequency discrimination, no significant differences were found for 196 Hz or 263 Hz between conditions. However, results for 1176 Hz showed that performance significantly decreased from baseline when spectral blurring was applied to the apical region ($p = 0.03$) or all channels ($p = 0.002$). Results for 3136 Hz showed that performance significantly decreased when spectral blurring was applied to all channels compared to all other conditions ($p's < 0.05$). For tone in noise detection, no significant differences were found for 196 Hz, 263 Hz, or 3136 Hz. However, results for 1176 Hz showed that performance significantly decreased when spectral blurring was applied to all channels compared to just the apical region ($p = 0.01$). For melodic contour identification, no significant differences were found for any base frequencies ($p's > 0.05$). Analyses will be re-run, including individual differences, once data collection is complete.

Conclusions: Music perception decreased with spectral blurring, particularly for base frequencies in the middle and basal regions. However, unlike speech, music perception did not significantly differ from baseline with IGES, suggesting a meaningful reduction in channel interaction was not achieved for these tasks. Taken together, channel interaction may impact music and speech differently, suggesting that potential programming strategies aiming to reduce channel interaction may need to differ for each domain to maximize performance.

Category: Cochlear Implants

Poster #: 019

Modeling Individual Effects of Context and Masking on Speech Recognition

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Objectives: When evaluating speech recognition accuracy in clinical and research settings, scoring partially correct responses can increase measurement precision, such as scoring by the number of phonemes correct in a word or words correct in a sentence. Interpreting partially correct responses can be challenging because meaningful speech contains contextual cues. Contextual cues create dependences between tokens within speech, such that the probability of correctly identifying one token depends on whether other tokens were correctly identified. Mathematically, these dependences within speech stimuli can be characterized with a beta-binomial distribution. A beta-binomial distribution is a generalization of the binomial distribution that models intraclass correlations in recognition accuracy between tokens within a stimulus. Thus, this distribution can be used to estimate both recognition accuracy and the interdependency of tokens within trials. In the present study, we use beta-binomial distributions to examine estimate individual differences in accuracy and intraclass correlations to test for the existence of individual variability in contextual use and stream segregation.

Design: In experiment 1, post-lingually deafened listeners with cochlear implants (N = 20) heard and repeated aloud 250 Minimum Speech Test Battery consonant-nucleus-consonant (MSTB CNC) words and 36 Perceptually Robust English Sentence Test Open-set (PRESTO) sentences. Responses were scored as the number of phonemes correct within words or the number of keywords correct within sentences. Bayesian models were fit to the data which had either fixed or variable intraclass correlation across participants, and goodness-of-fit was compared across models. In experiment 2, young adults with normal hearing (N = 30) listened to Basic English Lexicon (BEL) sentences in speech-shaped noise or two-talker maskers at fixed signal-to-noise ratios selected to yield 50% keyword recognition accuracy for each participant. Bayesian models were fit to the data to determine whether intraclass correlations varied across individuals in each listening condition.

Results: In all experiments, beta-binomial distributions provided a substantially better fit to the data than binomial distributions, although estimates of recognition accuracy were equal across distributions. In experiment 1, listeners with cochlear implants substantially differed from one another in recognition accuracy, but not in intraclass correlations. In experiment 2, young adults with normal hearing substantially differed from one another in intraclass correlations despite all participants being tested at a speech reception threshold that equated accuracy across participants. Individual differences in intraclass correlations were correlated across noise and two-talker maskers.

Conclusions: Fitting speech recognition data with beta-binomial distributions estimates accuracy and intraclass correlations, which provides complementary information about individual differences in speech recognition ability. Post-lingually deafened listeners with cochlear implants have variable speech recognition accuracy, as expected, but did not differ from one another in their use of contextual information to facilitate speech recognition. Young adults with normal hearing differed from one another in intraclass correlations in masked speech recognition, which could be related to different cognitive abilities than those which determine recognition accuracy.

Category: Cochlear Implants

Poster #: 020

Factors that Impair Binaural Unmasking Benefit in Cochlear Implants Users

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Objectives: Binaural hearing helps listeners navigate complex acoustic environments by allowing them to identify where sounds are coming from and hear out a speaker of interest in background noise. For normal hearing individuals, binaural benefits stem from the ability to integrate information across ears and fuse correlated sounds into a single percept. In contrast, individuals with cochlear implants (CIs) may perceive two distinct representations of the same sound due to across ear asymmetries that reduce interaural correlation. For example, individuals with bilateral CIs (BiCIs) may have interaural differences in neural health, electrode placement, and processor settings. Individuals with one CI and one hearing aid (Bimodal) have two separate modes of hearing, different processing delays between devices, place of stimulation mismatch, disparate spectral information, and differences in the fidelity of peripheral encoding across ears. Consequently, CI users demonstrate reduced binaural benefits like binaural unmasking, and some experience interference: a decrement in performance when listening with two ears versus one. This likely results from poor binaural fusion, which is a prerequisite for unmasking and is negatively impacted by interaural asymmetries. An increasing number of CI patients now have preserved low frequency hearing in their implanted ear and can utilize unilateral electric and bilateral acoustic stimulation (EAS). Previous work has shown additional benefit of EAS over bimodal hearing, but its effect on binaural integration has not been comprehensively examined. Therefore, the goals of this study were to 1) examine binaural integration using a novel speech fusion paradigm in BiCI, Bimodal, and EAS CI users, 2) relate binaural fusion to binaural unmasking of speech in the same listeners, and 3) investigate factors that may contribute to binaural outcomes, including interaural speech asymmetry, poorer ear performance, listener age, and selective auditory attention.

Design: Binaural unmasking was quantified by comparing CRM sentence intelligibility with a monaural target and masker to sentence intelligibility with a monaural target and bilateral masker. Listeners who can combine masker stimuli across ears perceive a perceptual separation of target and masker, resulting in improved performance (i.e., unmasking). Binaural speech fusion was measured using a vowel identification task, in which the first and second formants were presented to opposite ears. Finally, ear specific selective auditory attention was measured by comparing IEEE sentence intelligibility in quiet to a condition with a masker presented contralaterally.

Results: Preliminary binaural unmasking results from five BiCI adults showed interference for four listeners in at least one ear. Two listeners demonstrated asymmetric intelligibility in quiet, and both listeners also demonstrated interference in both ears. Interference was greater in the poorer ear, suggesting selective attention was also poorer for this ear. In contrast, of the three listeners with symmetric intelligibility in quiet, two demonstrated a small amount of interference in their left ear, and the other demonstrated unmasking in their right ear.

Conclusions: Additional data for all three CI groups will be presented, affording an improved understanding of factors hindering binaural processing in CI listeners, with the ultimate goal being improved clinical management of these patients.

Category: Cochlear Implants

Poster #: 021 **T35 Research Trainee Poster**

Pediatric Temporal Binding Window Training

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Objectives: Cochlear implants (CI) help individuals with significant hearing loss in many areas of their lives by offering access to auditory inputs assisting with sound awareness, speech understanding, and downstream processes such as speech, language, and reading. CIs have some limitations, however. Due to the nature of electrical stimulation, the signal received at each electrode spreads and interacts with the signals from the other electrode sites. This spread of excitation creates a degraded auditory signal associated with poor spectral resolution that limits a person's ability to interpret auditory signals when received alone. However, communication is a multisensory experience, with visual inputs significantly aiding auditory information, even for listeners with normal hearing. Because sound and light travel at different speeds, over time the brain learns which auditory signals are correlated with which visual inputs to gain the benefit of multisensory information. The time period over which multisensory information is bound together perceptually is called the temporal binding window (TBW). The TBW is known to narrow with age and become more visually biased. The TBW has been shown to be malleable in young and normal hearing subjects, with training resulting in a narrowing of the window. However, the impact of such plasticity of the TBW manipulation is not fully understood, particularly for younger and hearing impaired subjects. Thus, the present study investigated whether the TBW in children with CIs could be manipulated through simultaneity judgment (SJ) training. Based on data from other clinical populations, our hypothesis was that SJ training would significantly narrow the TBW for children with CIs, thereby improving their multisensory integration with cascading effects on audiovisual communication.

Design: This study included five children with bilateral CIs aged eleven to sixteen (mean thirteen years). All participants were implanted at age one or younger. The protocol was administered over three days and included the following assessments: monosyllabic words in noise for auditory only, visual only, and audiovisual conditions, and a SJ training task. All tasks were administered on days one and three whereas the SJ training task was administered all three days. The SJ task was administered at varying levels of difficulty on each day and throughout each day.

Results: Results to date showed no significant change in the width of the TBW and no significant changes in the magnitude of audiovisual integration. However, following training, TBWs shifted to be more visually biased than was expected for this age group.

Conclusions: This study explored how the TBW could be manipulated to better understand multisensory integration for children with CIs. Although the widths of the TBWs were not altered over the course of the training protocol, the shift toward more visually biased windows was an unexpected finding. Children's TBWs mature with age as their brain learns how to effectively integrate multisensory information. This plasticity could offer insight into the resistance to change in TBW width. The TBW and manipulation of the TBW is not well understood in CI users and thus this study offers key insights into areas for future studies.

Category: Cochlear Implants

Poster #: 022 **T35 Research Trainee Poster**

The Impact of Acoustic Hearing on Music Spatialization

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Objectives: Music spatialization is the ability to locate and follow musical sound sources, which contributes to creating a more immersive and engaging listening experience. Spatialization is achieved through panning, which redistributes the signal level from one output to another. Cochlear implant (CI) users typically perform worse than their normal hearing (NH) peers on tasks of horizontal localization and music perception. Electroacoustic stimulation (EAS) affords better horizontal localization and speech understanding in noise than electric stimulation alone through binaural access to low-frequency information, but its potential benefit for music perception over bimodal listeners with monoaural acoustic hearing is unclear. Therefore, this study aimed to compare music spatialization in CI users with varying amounts of acoustic hearing, including bilateral CI (no acoustic hearing), bimodal (contralateral acoustic hearing), and EAS (bilateral acoustic hearing). Our hypotheses were 1) EAS users would demonstrate better music spatialization ability compared to bimodal CI users, given potential access to low-frequency interaural time differences (ITDs), and 2) bilateral CI and EAS users would exhibit similar music spatialization ability, but mediated through different cues, namely, ITDs for EAS and interaural level differences (ILDs) for bilateral CI.

Design: Fifteen adults with NH and nine adults with CIs (planned N = 30, 10 in each CI group) participated. Music spatialization was assessed using a new task that asked participants to identify whether the music ended in the left or right loudspeaker. Stimuli included 80 different 22-second clips of "Happy Birthday" that varied in combinations of six musical lines (melody, harmony, rhythm, bass line, female voice, and male voice) and four panning configurations (left/right, right/left, right/left/right, and left/right/left). Additional tasks included ITD and ILD thresholds for 250- and 500-Hz tones, binaural intelligibility level difference (BILD), speech in noise via BKB-SIN (Etymotic, 2005), and musical contour identification (MCI; Galvin, 2007).

Results: As expected, NH listeners demonstrated ceiling-level performance on the music spatialization task with a mean score of 98.9%. The NH listeners also demonstrated expected mean scores for ITD and ILD thresholds (61.2 μs and 1.7 dB), BKB-SIN SNR-50 (-1.9 dB), and the MCI (93.9%). In contrast, preliminary results for the CI listeners indicated near chance-level performance on the music

spatialization task for all groups, with a mean score of 60.2%. ITD and ILD thresholds were highly variable for the CI group ranging from near-normal (266.1 μs and 1.4 dB) to a complete lack of ITD or ILD resolution for ecologically valid cues (930.6 μs and 10.7 dB, respectively). For the CI group, mean BKB-SIN SNR-50 scores were 7.9 dB (range: 2.5-20.5 dB) and mean MCI scores were 79.8% (range: 18.5-100%). Statistical analyses will be completed once data collection is finalized.

Conclusions: CI users demonstrated poorer speech understanding in noise, ITD and ILD sensitivity, musical contour identification, and music spatialization abilities than NH listeners. Contrary to our hypotheses, no advantage was found for EAS or bilateral CI in music spatialization over bimodal listeners. Further exploration is needed to understand how bilateral low-frequency acoustic input affects the perception of speech versus music.

Category: Cochlear Implants

Poster #: 023 **T35 Research Trainee Poster**

A Diverse Stimulus Set for Emotion Recognition: A Validation Study

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Objectives: The perception of emotional prosody plays a crucial role in effective communication. Cochlear implant (CI) users face difficulties in recognizing emotional prosody due to spectro-temporal limitations in the transmitted signal. This research aimed to create a diverse radical/ethnic stimulus set for assessing emotion recognition in both typically hearing and CI listeners, considering the influence of racial/ethnic backgrounds on emotion perception. The goal is to make emotion recognition assessments more relevant to real-life experiences by including diverse talkers in the stimulus set, reflecting the diversity of listeners and talkers in U.S. society. As a first step, we compiled a database of stimuli consisting of recordings of emotional speech recorded by African Americans, Hispanics/Latinos, and White talkers, all native speakers of U.S. English. The primary research questions were: 1) can emotion recognition be predicted by talkers' race/ethnicity and sex differences? 2) how would emotion recognition be altered by cochlear-implant simulated degradation in the stimuli? 3) how would cochlear implant users' recognition of emotions in this set of stimuli differ from the performance of listeners with normal hearing?

Design: Ten participants from various racial/ethnic groups, including African Americans and Hispanics/Latinos, all native speakers of U.S. English, were recruited to record the stimuli. The participants read 14 sentences that were semantically emotion-neutral, each with five different emotions (i.e., Happy, Scared, Neutral, Sad, and Angry). From this pool of talkers, one male and one female talker from each racial/ethnic background were selected based on the results of pilot studies with two listeners, ensuring that mean emotion identification scores fell within comparable ranges. The final stimulus set comprised recordings by 6 talkers (1 female and 1 male each identifying as White, African American, or Hispanic/Latino), each having recorded the same 2 sentences, each in the five emotions, resulting in a total of 60 recordings. For validation, 20 adults with typical hearing, whose primary language was English, participated. They completed a vocal emotion recognition task with the stimuli presented in

various versions, including full-spectrum, 4-channel, 8-channel, and 16-channel noise-band-vocoded formats. Acoustic analysis of the emotional speech materials was also completed.

Results: Preliminary regression modeling revealed that the spectral degradation condition had a significant effect on emotion identification accuracy. There were no main effects of race/ethnicity or talker sex, to be expected as the talkers were selected based on roughly similar scores in the pilot study. Consistent with prior research, emotions in the full spectrum condition were best understood, followed by the 16, 8, and 4 channel conditions. No interactions were found between talker race/ethnicity and spectral degradation or emotion. The only interaction involving talker race/ethnicity was with talker sex, due to a larger difference between the female and male Hispanic/Latino talkers than the other groups. Acoustic analyses showed distinct patterns of mean voice pitch, voice pitch fluctuations, duration, and intensity across emotions and talkers. Studies with cochlear implant listeners are currently ongoing.

Conclusions: This stimulus set can be used in future studies and represents a step forward in the direction of developing more diverse stimuli in our field.

Category: Cochlear Implants

Poster #: 024 **Mentored Student Research Poster Award**

Frequency-to-Place Mismatch and Cochlear Implant Acclimatization: What Factors Really Matter?

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Objectives: While the intracochlear position of an electrode array is patient specific, the default frequency filter of the cochlear implant (CI) is standardized. As a result, every patient has varying degrees of frequency-to-place mismatch between the natural acoustic mediated tonotopic organization of the cochlea and the electric frequency allocation. This mismatch can be perceived as degradation of the signal provided by the CI. The plasticity of the human auditory system has been shown to help in perceptual adaptation to this mismatch, but at varying rates. To date, the precise influence of this mismatch remains unclear - with small samples unable to capture the combined influence of electrode array, electrode position, age, residual hearing, and device use. Therefore, this study aims to better quantify frequency-to-place mismatch and a patient's rate of acclimatization, while controlling for various clinical factors, including electrode array, age, acoustic hearing preservation, and device use.

Design: A retrospective chart review identified adult CI users with postoperative computerized tomography (CT) scans which were processed using validated techniques for electrode placement factors. These factors included scalar location, modiolar distance, angular insertion depth, and spiral ganglion place frequency - for each electrical contact in the array. From these measurements, frequency-to-place mismatch was calculated for the most apical electrode as well as the electrode representing 1500 Hz, to represent the approximate spectral center of speech. Additional review of patient related

outcomes is ongoing, identifying electrode array type, age at implantation, acoustic hearing (ipsilateral and contralateral), daily device use (datalogging), and speech recognition outcomes (word recognition and sentence recognition in quiet and in noise at 1-, 3-, 6-, and 12-months post CI activation). We currently have 274 individual ears in our sample, with an anticipated final sample of 500 ears.

Results: Preliminary results did not show a significant effect of mismatch at 1500 Hz at 1 month ($F(91, 176) = .840$, $p = .792$, $\eta p2 = .482$), 3 months ($F(89, 171) = .862$, $p = .752$, $\eta p2 = .493$), 6 months ($F(84, 155) = 1.039$, $p = .438$, $\eta p2 = .562$), or 12 months ($F(75, 130) = 1.209$, $p = .235$, $\eta p2 = .637$) post-activation. Datalogging was a significant predictor of word recognition scores at all 1-, 3-, and 12-months ($p's < 0.05$), while age was not a significant predictor at any time point. Additional analyses including all the variables measured will be completed once data collection is complete.

Conclusions: The results of this study suggest that the relationship between frequency-to-place mismatch and word recognition is not significant when clinical factors, including age and daily device use, are considered. While the interactions of these metrics warrant further examination, these preliminary findings suggest that degradation resulting from frequency-to-place mismatch may be overcome by consistent device use.

Category: Cochlear Implants

Poster #: 025

An Objective Measure of Binaural Cue Sensitivity

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Objectives: Electric and acoustic stimulation (EAS) is an auditory intervention combining cochlear implant and hearing aid technology within and across ears to optimize broadband auditory access. EAS is an increasingly prevalent cochlear implant (CI) intervention for patients with precipitously sloping high-frequency hearing losses. However, much like other CI configurations, EAS yields outcomes that are variable across patients and this variability is not well explained by the underlying audiogram. Instead, research has shown that EAS benefit is significantly correlated with binaural cue sensitivity-namely interaural time differences (ITD)-in the acoustic hearing domain with the most robust effect observed for fine structure ITD sensitivity. Currently, ITD sensitivity is typically measured using behavioral methods that are time-consuming and require listener training, which limits clinical feasibility. However, previous research has demonstrated the efficacy of the acoustic change complex (ACC), which imposes an interaural phase difference (IPD)-equivalent to ITD for steady periodic tones-as an objective marker of binaural cue sensitivity. Data from 10 listeners with normal hearing suggest that 1) ACC amplitude increases with IPD, and 2) ACC-based IPD sensitivity with a 250-Hz carrier was significantly correlated with behavioral fine-structure ITD thresholds. The purpose of the current study was to apply this experimental paradigm to adult listeners with bilateral sensorineural hearing loss meeting EAS candidacy. Our hypothesis was that there would be a significant correlation between ACC amplitude and IPD as well as ITD thresholds and BILD.

Design: We measured fine structure ITD/IPD sensitivity using both behavioral and objective methods. Behavioral measures included fine structure ITD thresholds and a binaural intelligibility level difference (BILD) task using spondees presented as phase correlated (N0S0) and phase inverted (N0Spi), relative to the broadband masker. Objective measures included the IPD-mediated ACC with binaurally presented 250-Hz carrier (1.6 sec) that was sinusoidally amplitude modulated at 40 Hz. The following IPDs were imposed at stimulus midpoint in one ear: 0, 45, 90, 135, and 180 degrees.

Results: Our preliminary results with 3 study participants (12 planned) indicate that: 1) In contrast to the findings from listeners with normal hearing, ACC energy for individuals with hearing loss did not systematically increase with IPD nor was the maximal ACC N1-P2 response observed for 180 degrees, 2) Similar to the listeners with normal hearing, participants' IPD sensitivity as measured via ACC was positively correlated with behavioral ITD sensitivity, 3) As expected, participants' ITD thresholds were inversely correlated with BILD, and 4) There was a positive relationship between ACC N1-P2 energy and BILD.

Conclusions: In summary, given the relationship between behavioral and objective measures of binaural cue sensitivity for adult listeners with EAS-qualifying hearing losses, it is possible that the use of the IPD-mediated ACC could help identify CI users with bilateral acoustic hearing who might benefit from EAS and could also potentially be administered in the preoperative period to gauge binaural cue sensitivity for expectations management, patient counseling, and even electrode selection.

Category: Cochlear Implants

Poster #: 026

Visual Influences on Prosody Perception Among Listeners with Cochlear Implants

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Objectives: Understanding a talker's intention conveyed through prosody is a critical aspect of successful speech communication. Difficulty perceiving prosody is a common patient report and experimental finding among listeners who use cochlear implants (CIs). One compensation strategy that these listeners might deploy in everyday life is to rely on visual prosody cues conveyed through head and eyebrow movements. Using an audio-visual cue weighting approach, this study tests the following hypotheses: 1) visual cues indicating the presence or absence of a prosodically focused word will bias auditory perception of word focus; 2) the degree of this visual influence will be greater for listeners with cochlear implants than those with typical hearing; and 3) for CI listeners, perception of a focused word will be stronger when visual cues are available than in audio-only listening.

Design: Natural audio-visual recordings were made of a talker saying short sentences, in which either no words were emphasized (broad focus) or one word was emphasized as if correcting false information (corrective focus). To test the influence of visual cues on perceiving this type of prosody, we constructed transplant stimuli in which the auditory cues suggested a focused word while the visual cues suggested broad focus, and vice versa. In an additional control condition, participants heard the auditory stimuli in

isolation. Prosody perception and production were assessed simultaneously using a vocal mimicry task, in which participants were asked to repeat back each stimulus with the same prosody they perceived. Participant F0 was tracked using the pitch autocorrelation algorithm in Praat to calculate differences in vocal production that resulted from the presence of visual cues in the stimuli. Data will be presented from 14 cochlear implant listeners and 18 typical hearing listeners.

Results: F0 contour - a key acoustic marker of prosodic focus - is biased by naturally occurring visual prosody cues. Specifically, for sentences spoken without any particularly focused words, vocal reproductions showed a slightly higher F0 on words paired with visual cues that indicated prosodic focus. Similarly, words that were spoken with corrective focus were reproduced with a slightly lower F0 when paired with video lacking prosodic gestures. This pattern is more exaggerated among some CIs listeners, indicating greater reliance on visual cues for prosody perception, in addition to the well-known reliance on visual cues for phonetic information.

Conclusions: Visual cues provide prosodic information during speech recognition, and a novel way of assessing visual prosody perception is analysis of listeners' spoken reproduction of F0 contours. These visual cues bias listeners' perception of prosodic contour, highlighting the role of multisensory information in understanding natural prosody. This underscores the importance of considering audio-visual speech processing when assessing real-world communication success.

Category: Cochlear Implants

Poster #: 027

Environmental Sound Comprehension in Cochlear Implant Users

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Objectives: Cochlear implants (CI) have transformed the lives of many individuals with hearing loss by improving their speech perception abilities. Yet, the extent to which CI users obtain benefit in environmental sound perception has not been rigorously investigated and remains unclear. Although anecdotally CI users and clinicians tend to report improved environmental sound awareness, limited research mostly indicates clear deficits and a lack of overall improvement relative to pre-CI performance. A possible reason for this discrepancy may be the overreliance of past studies on environmental sound identification tasks, which involve linguistic processing involved in sound naming. The purpose of this study was to investigate the performance of CI users on alternative tasks that do not require explicit naming but involve the processing of semantic properties of individual sounds and their auditory context.

Design: Cochlear implant users and normal hearing control (NH) participants were tested on three separate perceptual tasks that tapped into different aspects of perceptual, linguistic and cognitive processing of environmental sounds. First, participants (16 CI, 13 NH) were presented with triplets of individual environmental sounds that differed in their semantic properties and were asked to pick one sound that "did not fit" with the other two (e.g. rooster -siren - duck). Second, participants (10 CI, 10 NH)

were presented with each sound from the previous task and asked to identify it by selecting one of 35 sound names. In the final task, participants (18 CI, 13 NH) heard naturalistic auditory scenes and were asked two questions about each scene that required making an inference about objects and events in the scene without explicitly naming them (e.g. 'which time of day does this scene most likely take place?').

Results: Group-level analysis indicated performance differences across the three tasks. For the first triplet task that involved semantic processing without explicit naming, performance of CI users most approximated that of NH controls: mean 82% (SD=12.1) vs. 94% (SD=9.6) respectively. For the second identification task performance difference between CI and NH participants increased and was comparable to that reported in prior studies: mean 64% (SD=12.5) vs, 90% (SD=9.3), respectively. For the third task, the difference between CI and NH listeners decreased slightly: mean 69% (SD=16.2) vs. 88% (SD=10.0), respectively.

Conclusions: The present findings indicate that perception of environmental sounds and their semantic properties is modulated by task requirements. There was a greater performance decrement in CI users, relative to NH controls, in tasks with a greater information processing load such as sound naming or auditory scene comprehension. In contrast, the gap between CI and NH listeners decreased in a task that involved categorization and discrimination without explicit naming. These findings suggest that a battery of environmental sound tests that tap into different aspects of environmental sound perception abilities can provide a more comprehensive assessment of CI benefits, with potential to inform the counseling of CI candidates and continuing rehabilitation of CI users.

Category: Cochlear Implants

Poster #: 028

Computational Modeling of the Electrode-Neuron Interface to Optimize Speech Outcomes

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Objectives: Speech-perception outcomes are highly variable among cochlear implant (CI) listeners and can be greatly affected by programming strategies. Some subjects perform well with monopolar (MP) strategies, which broadly activate neurons, whereas other users demonstrate improved performance when current is focused towards a narrower tonotopic region, as is the case with tripolar (TP) stimulation. A goal, then, is to use clinical assessments and computational modeling to determine who benefits and what the underlying reason may be, in order to direct changes in clinical programming to maximize outcomes for any given listener.

Design: The difference in outcomes between monopolar and focused stimulation strategies is likely driven by factors at the electrode-neuron interface (ENI) affecting the spread of current, including: 1) electrode-to-neuron distance and 2) neuron cell survival. A model previously developed by our group was used and inverted to approximate these two factors based on monopolar and tripolar stimulation

thresholds in 5 adult subjects (6 ears total) acquired by a MP and TP sweep procedure. Specifically, we used this simplified cylindrical cochlear model, which calculates monopolar and focused stimulation thresholds from assumed electrode distances and relative neuronal densities along the length of the implant. We then used nonlinear multidimensional least-squares fitting to invert the model. Input to the model was listener-specific monopolar and focused threshold profiles, and inferred electrode distance and neuronal density that best reproduced the input threshold profiles simultaneously. In these same listeners, clinical medial vowel identification (h/v/d) and IEEE speech assessments in noise were performed for monopolar and dynamic tripolar strategies with channels with the highest focused thresholds deactivated. For dynamic tripolar stimulation, the degree of focusing varied dynamically-using more focused stimulation for soft sounds to less focusing for louder sound input levels. A key hypothesis was that dynamic focusing would result in improved speech perception, specifically in subjects where model-predicted electrode proximity was close and inferred neuronal counts were large.

Results: Consistent with previous studies, focused threshold profiles across 6 ears varied greatly. In all subjects the median performance on speech in noise perception for vowels and sentences was best with dynamic focusing. The model predicted that focusing had the largest impact on improving speech outcomes in subjects with smaller electrode-to-neuron distances. The model predicted that the electrode-to-neuron distances were smallest for subjects who received the peri-modiolar array and furthest for subjects who received lateral wall arrays, consistent with electrode designs and intended placement.

Conclusions: Program optimization using monopolar and dynamic focused stimulation strategies, with channel deactivation, has mixed results - yet some subjects show tremendous improvement with focusing strategies. In these patients, the computational model predicts smaller electrode-to-modiolar distances and various degrees of residual SGN survival. Additional investigation is needed to further understand the role of the ENI and to develop methods to optimize and individualize programming approaches.

Category: Cochlear Implants

Poster #: 029

Impact of Vocoding on Spectrally Modulated Transfer Function in Children

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Objectives: Spectral resolution, ability to perceive modulation in intensity across frequency in complex sound is an important factor that predicts device efficacy in adult cochlear implant (CI) listeners. CI listeners have poor spectral resolution for several reasons including limited number of electrodes and spread of neural excitation with electrical stimulation. Frequency resolution (FR,) resolution of spectral place of modulation, and spectral modulation sensitivity (SMS,) ability to detect changes across-spectrum intensity, are two independent factors that relate to spectral resolution that can be assessed using spectrally modulated transfer function (SMTF) where FR is slope and SMS is intercept. FR matures in

infancy while SMS matures later in adolescence. FR has been shown to be related to speech understanding in adult CI listeners. The "standard" procedure to derive SMTF requires several assumptions about the parameters of the function. We have developed a new procedure, maximum-likelihood (ML) adaptive procedure, to derive SMTF that tests stimuli on a trial-by-trial basis which is iteratively optimized, rather than having predetermined stimuli sequence. We will examine the effect of spectral degradation of stimuli on SMTF parameters. We will compare derived SMTF parameters from two groups of listeners; each group will test with one procedure with unfiltered and vocoded stimuli. Vocoding should reduce slope but not intercept. We hypothesize 1. No difference exists in mean slope and intercept for the procedures. 2. Spectral degradation will lower slope but not change intercept.

Design: Participants are children aged 5-12 years who passed screening audiograms and report normal hearing. Stimuli include 1s broad-band noise with spectrally "rippled" envelopes of various ripple densities. Stimuli were also filtered through 8 and 4-channel noise vocoder. Participants determined a target stimulus (ripple density<20/octave) from two distractors (=20/octave.) For the standard procedure thresholds were determined by varying modulation density in 3-AFC, 2-up, 1-down staircase at 4 fixed ripple depths until 10 reversals. SMTF parameters were derived from a log-function fit to this data. The ML-adaptive procedure varied modulation depth and density determined by the model. Participants completed testing with unfiltered and filtered stimuli. Unpaired t-tests were used to compare each method between subjects by stimulus type (filtered and unfiltered) and ANOVA will be used to compare both methods with both stimuli type.

Results: To date, we have tested 11 children with the standard procedure. Vocoded stimuli significantly decreased slope (worsened) and decreased intercept (improved) using the standard procedure. Testing is ongoing for ML-adaptive procedure.

Conclusions: Standard procedure shows the expected effect of vocoding on slope but unexpectedly appears to have "better" modulation sensitivity with vocoding. We suspect this is artifactual due to fitting the logarithmic curve and will not exist with ML procedure.

Category: Cochlear Implants

Poster #: 030

The Effect of Bilateral Cochlear Implant Use on Vocal Emotion

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Objectives: The ability to express emotion through vocalization relies on the ability to adjust both vocal pitch and intensity. It is known that bilateral cochlear implant (BiCI) users struggle to accurately control both of these aspects of their voice, particularly when compared to only using one CI. The goal of this study was to investigate the difference in vocal emotion for bilateral CI users when using one CI, both CIs, and no CI.

Design: Recordings were made of 3 participants' vocalizing sentences with various vocal emotions. Recordings were made with both CIs on (BiCI), no CIs on (NoCI), using only the right CI (RightCI), and using only the left CI (LeftCI). The spoken sentences were recorded using a head-worn microphone that was placed approximately 5cm from the participant's mouth. Acoustic analysis for the standard deviation (SD) of the fundamental frequency (F0) and the intensity variation (vAm) was performed using custom software written in Matlab. Participants were recruited through cochlear implant Facebook groups and discussion forums.

Results: Producing a happy vocal emotion normally involves larger variations in both F0 and intensity. Greater amounts of variation in F0 occurred in the BiCI condition compared to the NoCI condition. In contrast, F0 variation was greater when using only one CI compared to when using both CIs.

Conclusions: The results suggest that BiCI use yields less of the variations that are typical of a happy vocal emotion compared to unilateral CI use, although BiCI use does aid in modulating F0. Further analysis will reveal if these findings are consistent across various vocal emotion productions.

DIAGNOSTIC AUDIOLOGY / OTOLOGY

Category: Diagnostic Audiology / Otology

Poster #: 031

Longitudinal Hearing Phenotype in Patients with Neurofibromatosis Type 2

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Objectives: Neurofibromatosis type 2 (NF2) is an autosomal dominant condition resulting from mutation of MERLIN, a tumor suppressor gene, that is characterized by bilateral cochleo-vestibular schwannomas (CVS) and other nervous system tumors. The classic presentation of NF2 includes tinnitus and hearing loss due to cochlear and retrocochlear dysfunction. While there is not a clear relationship between tumor size and the degree of hearing loss at a given point in time, a systematic investigation of dynamic changes in hearing and tumor growth over time is warranted. The goal of this study was to better characterize the relationship between hearing progression and CVS specific growth rates (SGR) in patients with NF2.

Design: This is a longitudinal prospective natural history study (NCT00598351) investigating clinical characteristics, including audiovestibular function, of patients with NF2. The study comprised 125 individuals with NF2 (M 30.7 yrs; SD 17.13; 4-71 yrs; 61 males) seen between 08/2006 and 10/2022 for annual assessments with a mean of 5 visits (range, 1-16) per patient. Comprehensive audiological evaluation consisted of middle ear testing, air and bone conduction hearing thresholds , and speech audiometry. Median time to significant hearing decline was determined using Kaplan Meier analyses with a hearing decline event defined as a change in air-conduction 4-frequency pure tone average (4-F-PTA) of >10dBHL. Data were examined for hearing decline event s from all ears having 4-F-PTA between -10-80dBHL (n= 197) and from those ears with baseline hearing loss defined as a 4-F-PTA >20 dBHL (n=108). Linear regression analyses investigated relationships between CVS-SGR and hearing progression.

Results: There was no significant difference in median hearing decline between right and left ears and ears were subsequently combined for all analyzes. There was a significant earlier median time to hearing decline when analyzing ears with at least a mild hearing loss 4-F-PTA at baseline (36 months) compared to all ears inclusive of normal 4-F-PTAs (77 months), $p<0.0001$. While including ears with a normal baseline 4-FPTA creates a significantly younger group (M=30.7 yrs ÔÇ±17.1) than only those patients with hearing loss at baseline (M=35.8 yrs ÔÇ±16.6), p=0.0016, these data may be consistent with a known 2-2.5-year delay in hearing decline following MRI FLAIR signals in CVS tumor status reported to precede auditory changes .

Conclusions: These findings identify a 36-month median time to a significant hearing decline for patients with NF2 having at least a mild hearing loss 4-F-PTA at baseline. When including those with normal hearing sensitivity, the median time to hearing decline increases to 77 months. These data suggest that there is a critical dormant period before CVS growth alters the cochlear hemostasis to result in significant hearing loss and the previous observation of delayed onset of hearing loss following MRI FLAIR signal changes. These data will also highlight predictive relationships between CVS SGR and hearing progression as well as the mechanism of hearing loss caused by CVS .

Category: Diagnostic Audiology / Otology

Poster #: 032

Ototoxicity Management in Patients with Nontuberculous Mycobacterial Infections

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Objectives: Aminoglycosides are potent broad-spectrum antibiotics that may be used to treat serious infections caused by both gram-positive and gram-negative bacteria, as well as multidrug resistant bacteria. Individuals undergoing treatments may experience ototoxicity, or permanent hearing loss, tinnitus, or balance/vestibular difficulties, following aminoglycoside exposures. The estimated prevalence of aminoglycoside ototoxicity has been reported to range from 2% to 25% and may exceed 50% for patients who require multiple or prolonged courses of aminoglycoside treatments, such as individuals with nontuberculous mycobacteria (NTM) infections. NTM composes a heterogenous group of over 200 organisms that can be found in environmental sources, such as soil and water. NTM infections

more frequently occur among patients who are elderly, immunocompromised, after surgery/trauma, or with forms of chronic lung disease. Guidelines for ototoxicity monitoring of individuals treated with aminoglycoside antibiotics secondary to NTM infection have not been established. Despite well-established physical, socio-economic, and psychological consequences of hearing and balance dysfunction, ototoxicity management is not standardized. The purpose of this project is to characterize the audiologic care and profile of patients with NTM infections receiving ototoxic treatments and to outline serial measurement approaches for the clinic.

Design: Retrospective data reviewed from 21 individuals (7 male, 13 female, 1 undisclosed; ages 50-87 years) referred to the Division of Audiology while undergoing NTM treatment over a one-year timeframe. Audiometric data were obtained from the electronic medical records of 18 individuals (3 had no audiological records). The records were searched for audiologic results from all time and reported symptoms. Patients who had at least two audiograms for comparison were included in the study (n=14). Outcomes were determined relative to baseline evaluation (prior to aminoglycoside treatment) to quantify ototoxic changes (per ASHA 1994) and to explore serial measurement outcomes. Variables analyzed include hearing thresholds in the conventional (250-8,000 Hz) and extended high frequency range (up to 20,000 Hz), otoacoustic emissions, and immittance measures. Aminoglycoside treatment, type of infection, number and timeline of audiological evaluations, and self-report symptoms of hearing loss, tinnitus, or balance dysfunction were also reviewed.

Results: This study characterized the audiologic profiles and range of ototoxic exposures in individuals with NTM infections referred for audiological evaluation. Seven demonstrated evidence of ototoxic change relative to baseline while receiving aminoglycoside treatment. Extended high frequency thresholds were obtained in 41% of visits and otoacoustic emissions were obtained in 53% of visits. On average, individuals had 4.5 monitoring visits, yet there was great variation in this that did not align with treatment plans nor self-reported concerns.

Conclusions: Outcomes support development of consensus recommendations and approaches for ototoxicity management of individuals with NTM infections undergoing aminoglycoside treatments. These recommendations can be used to guide development of effective ototoxicity management programs, including appropriate scope and timing of monitoring. Since aminoglycoside-associated ototoxicity can be permanent and debilitating for patients, a standardized monitoring guideline is needed to minimize this toxicity. Moreover, further resource assessment of both providers and patients is needed to address how best to operationalize the monitoring for aminoglycoside ototoxicity.

Category: Diagnostic Audiology / Otology

Poster #: 033

Mapping Cardiovascular Disease Risk Status to Audiometric Phenotypes

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Objectives: Hearing loss is a significant clinical and public health problem and has been associated with psychosocial sequelae such as cognitive decline and depression. Compared to those with optimal cardiometabolic health, persons with cardiovascular disease (CVD) risk factors have higher prevalence of hearing loss. Past research is inconclusive regarding how audiometric configurations, or phenotypes, present in persons with CVD risk factors. Here we examine audiometric phenotypes in relation to CVD risk status.

Design: We conducted a retrospective review of clinical data from patients aged ≥18 years seen at an academic medical center. Persons with otologic pathology, sudden hearing loss, or who used ototoxic medications were excluded leaving an analysis sample of 6332. Cardiovascular risk factors assessed were diabetes, hypertension, hyperlipidemia, and tobacco smoking. We defined three groups: (1) lowest risk [reference group]: no risk factors or blood pressure (BP) ≤139/90 mm Hg or total cholesterol 180-199 mg/dL, (2) mid-risk: nonoptimal levels of 2 risk factors (BP ≤139/89 mm Hg or cholesterol 200-239 mg/dL) or 1 major risk factor (cholesterol ≥240 mg/dL or statins, BP ≥140/90 mm Hg or antihypertensives, diabetes, tobacco smoking), (3) high-risk: ≥2 major risk factors. Seven rule-based phenotypes were defined (strict normal hearing [NH] all thresholds ≤15 dB HL), NH (average of all thresholds ≤25 dB HL), strial, low sloping, mid sloping, high sloping, and notch (3, 4, 6 kHz). Multinomial regression was used to examine the association between better-ear phenotype and CVD risk status (lowest, mid, high). Models were adjusted for age, sex, noise exposure, and body mass index. Odds ratios (ORs) and 95% CI are reported.

Results: Data from 6332 patients were included: 2636 (46%) were male and the average age was 62.8 years (SD=14.60). Regarding CVD risk, 993 (17.2%) patients were lowest risk, 3140 (54.3%) were mid-risk, and 2063 (35.6%) were high risk. Distribution of phenotypes was as follows: notched (21.6%), NH (20.7%), strial (16.1%), strict NH (13%), high sloping (10.3%), low sloping (9.7%), and mid sloping (8.6%). Low CVD risk patients presented with all seven phenotypes; NH was their most common phenotype (23%). Most patients with strict NH (69%) were women and most with notched configurations (63%) were men. Mid CVD status was not associated with any of the phenotypes. High CVD risk was most strongly associated with mid-frequency sloping loss (OR=2.26 [95% CI:1.36, 3.75]). Compared to low CVD risk patients, those with high risk were more than twice as likely to have strial and notched audiograms (ORs=2.16 [1.36, 3.41] and 2.16 [1.44, 3.22], respectively). High CVD risk was also associated with low- and high-frequency loss (OR=1.87 [1.12, 3.10]); OR=1.83 [1.15, 2.90], respectively). Patients with high CVD risk also had increased odds of NH (OR=1.69 [1.17, 2.45]).

Conclusions: Patients with low CVD risk most often presented with strict NH or NH. Having ≥2 CVD risk factors elevated odds of hearing loss. We did not identify a distinct audiometric pattern associated with high CVD risk, but the strongest association was to mid-frequency sloping loss. Individual CVD risk factors or specific risk factor combinations may better map to phenotype.

Category: Diagnostic Audiology / Otology

Poster #: 034

Acoustic Reflex Testing for Differential Diagnosis in Conductive Hearing Loss

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Objectives: 1. Review audiologic practices for measuring acoustic reflexes in patients with air-bone gaps and tentative diagnosis of otosclerosis or superior semicircular canal dehiscence (SSCD), with attention to changes over time and institutional practice. 2. Evaluate relative predictive value of acoustic reflex presence compared with other common metrics (presence of conductive hearing loss, vestibular evoked myogenic potential thresholds, imaging, case history information) for otosclerosis versus SSCD in this population.

Design: We completed a retrospective review of all patients diagnosed with superior semicircular canal dehiscence (SSCD) and otosclerosis at the University of Colorado between January 2010 and January 2020. For each subject, demographic data and relevant history were reviewed. Four specific history factors were considered for their relevance to the underlying diagnoses (1. pulsatile tinnitus, 2. ear fullness/pressure, 3. autophony, 4. dizziness). Results from audiometric testing, including puretone/speech audiometry, immittance testing, and electrophysiology, as well pertinent imaging and surgical history, were recorded. Descriptive summaries of measures are provided as mean for continuous measures and as frequency for categorical measures. Prediction of SSCD versus otosclerosis is restricted to those with confirmed diagnosis via surgery. Logistic regression is used to estimate the association of predictors with binary outcomes. Results are summarized using the area-under-curve (AUC) and Brier score for both continuous and categorical definitions. The sensitivity and specificity are provided, with continuous predictors using a threshold identified by Youden's J statistic.

Results: Six-hundred, sixty-one patients met inclusion criteria, with 587 (88.8%) being diagnosed with otosclerosis and 74 (11.2%) with SSCD. Those with co-diagnosis or incorrect diagnoses were excluded. For all patients, only 35.4% had acoustic reflexes measured at the time of the first audiogram of record. Predictors for reflex measurement included female gender (OR 1.49, $p = 0.044$), having only one ear affected (OR 1.72, $p = 0.005$), and first audiogram occurring in-house (OR 2.04, $p = 0.003$). Those with a first audiogram in-house have a rate of reflex testing that is 8.7 times that of those tested externally ($p<0.001$). The proportion of first audiometric evaluations with reflex testing was relatively stable over the observed period. The best categorical predictors of an SSCD diagnosis compared with otosclerosis in patients with confirmed intraoperative diagnoses were 2 or more positive specific history factors (AUC 0.966, Brier 0.026), present reflexes (AUC 0.913, Brier 0.026), and imaging (AUC 0.998, Brier 0.012).

Conclusions: In our study, only about one-third of patients with a working diagnosis of otosclerosis or SSCD underwent audiometric testing patients that included reflex testing, which was more likely to occur at our institution and when only a single ear was affected. There is no evidence of increasing inclusion of reflex testing over time for these populations, despite the potential clinical utility. Acoustic reflexes and case history questions can reliably differentiate between otosclerosis and SSCD, which can be useful in determining which patients may benefit from more invasive work-up or surgery. Results highlight the importance of reflex testing, and which practitioners should be encouraged to include in diagnostic work-up to assist with differentiating between these challengingly similar populations.

Category: Diagnostic Audiology / Otology

Poster #: 035

Socioeconomic Status and Achievement of EDHI Benchmarks during COVID Pandemic

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Objectives: Early hearing detection and intervention (EHDI) benchmarks are screening before one month of age, diagnosis by three months of age (DIAG3mo), and enrollment in early intervention by six months of age (EI6mo). In March 2020, a national emergency was declared in the United States due to the COVID-19 Pandemic challenging families when navigating the EHDI process. For babies born in 2020, there was a reduction in the achievement of DIAG3mo and EI6mo. Socioeconomic factors may have played a key role in hindering the achievement of EHDI benchmarks during the COVID-19 pandemic. The purpose of this study was to determine if states' socioeconomic factors (median household income [$houseInc], % earning a >BA [%>BA], % employed [%employ], %<US federal poverty level [%<FPL], % w/o healthcare coverage [%noinsurance], and % of households speaking languages other than English [%otherlang]) predicted achievement of DIAG3mo and EI6mo during the COVID-19 pandemic.

Design: Data from the Centers for Disease Control 2020 EHDI statistics and the US Census Bureau American Community Survey were aggregated by state in this ecological study design. The data contained observations from 58 US states and territories, but three did not report resulting in regression samples of 55. Both %noinsurance and %otherlang were highly skewed toward zero so log transforms of both were successful in transforming them into normally distributed variables. DIAG3mo and EI6mo outcome variables were dichotomized<40% (poor) versus > or = 40% (marginal to good). Univariate logistic regression was used initially. Any predictor variable with a univariate p-value 0.15 or less was included into a multivariate model. Backwards selection was used to arrive at the most parsimonious model. SAS 9.4 was used for all analysis, and a 0.05 alpha level was assumed for significance.

Results: The log of %noinsurance was significantly different in univariate associations (p=0.0468) for dichotomous %DIAG3mo (<40% M=2.2%, SD=0.6%; >40% M=7.1%, SD=4.2). This significant variable, plus %<FPL and %otherlang were added to a multivariate model on dichotomous %DIAG3mo. However, only the univariate model was significant. The odds of having marginal to good %DIAG3mo was 72.2% (95%CI: 2.0, 92.2) less for each one unit increase of the log of %noinsurance. For %EI6mo, none of the univariate logistic regression scenarios were significant, and no variables were below the 0.15 univariate threshold to start a multivariate model. So, no multivariate model was attempted for the EI6mo outcome variable.

Conclusions: The log of %noinsurance was significantly different in univariate associations for dichotomous %DIAG3mo during the COVID-19 pandemic. It may be that parents without health care coverage did not follow through with timely audiologic evaluations. Future research should investigate obstacles in meeting EHDI benchmarks including staff shortages, facility closures, limited appointments for outpatient procedures, illness/quarantining, and parents' reticence to follow up during the COVID-19 Pandemic.

Category: Diagnostic Audiology / Otology

Poster #: 036

Cochlear Frequency Selectivity and Extended High Frequency Hearing in Listeners with Normal Audiograms

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Objectives: Some listeners with clinically normal audiograms may have elevated hearing in the extended high frequencies (EHFs: >8 kHz). Emerging research suggests that hearing in the EHFs may contribute to speech understanding in noisy environments. Additionally, some authors consider elevated EHF hearing thresholds as a sign of cochlear synaptopathy in the lower frequencies where hearing thresholds are normal. However, the mechanisms that may underlie perceptual deficits due to EHFs are not fully understood. One potential source of this difficulty could be subclinical changes in cochlear functioning, specifically, cochlear frequency selectivity. Reduced peripheral frequency resolution, a hallmark of cochlear hearing loss, impairs the ability to identify target sounds in background noise. Evidence suggests that stimulus frequency otoacoustic emission (SFOAE) delays can be applied to non-invasively assay cochlear tuning, and these measures corroborate well with psychophysical measures of frequency selectivity in normal hearing listeners. The objective of the present study was to test the hypothesis that elevated hearing in the EHFs is associated with broadened cochlear tuning in lower frequencies, as measured by SFOAE delays.

Design: Thirty-one young, healthy adults (19-30 year-olds) with clinically normal hearing thresholds (≤20 dB HL) in the standard audiometric frequencies (0.25-8 kHz) participated in this study. Swept-tone evoked SFOAEs were recorded from 0.5 to 4 kHz with 25- and 40-dB probe levels. The suppressor frequency was 1.1 times greater than the probe frequency. SFOAE delays were computed using the peak-picking method, and the sharpness of cochlear tuning (QERB) was computed using an empirical model. QERB was estimated at half-octave bins with center frequencies 1, 1.414, 2, and 2.828 kHz for the three probe levels. Additional measurements included wideband absorbance and hearing thresholds at 10, 12.5, and 16 kHz. Statistical analyses focused on examining the relationship between QERB and hearing thresholds at EHFs, while adjusting for the effects of other confounding variables, such as standard frequency hearing thresholds and SFOAE magnitudes.

Results: There was a significant effect of probe level and probe frequency on QERB. The effect of the pure-tone average for the EHFs on QERB was significant. This effect was center frequency and level dependent. Wideband absorbance had no effect on the QERB estimates, or on EHF hearing.

Conclusions: Listeners with elevated EHF hearing may have broadened cochlear tuning at lower frequencies despite clinically normal audiograms. This finding may suggest broadened cochlear tuning as a mechanism by which EHF hearing affects speech-in-noise recognition. This also suggests that EHF hearing loss could be a sign of subclinical auditory damage, and not all listeners with EHF loss have synaptic deficits in the lower frequencies. Clinically, findings highlight the importance of measuring EHF hearing thresholds.

Category: Diagnostic Audiology / Otology

Poster #: 037

Clinical Trial Advancement of ORC-13661 for Preventing Aminoglycoside-Induced Hearing Loss

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Objectives: ORC-13661 is a new chemical entity, specifically designed to prevent aminoglycoside-induced hearing loss. A screening hit was discovered using a unique zebrafish phenotypic screening platform. The same assay was used to increase potency. Additional secondary screens were used to minimize off target pharmacology while optimizing drug-like properties. ORC-13661 was selected as a clinical candidate because it provided exposure-proportional protection of amikacin-induced ototoxicity in rats treated daily for 10 or 14 days. Objectives for further clinical development program are: 1] investigate the safety and pharmacokinetic properties of ORC-13661 in healthy human volunteers (Phase 1); and 2] investigate the efficacy of ORC-13661 at two dose levels in patients with Non-Tuberculous Mycobacterium (NTM) disease requiring extended intravenous (IV)-amikacin therapy. A successful Phase 1 was completed and Phase 2 is currently underway.

Design: Phase 1 double-blind, placebo-controlled trial was conducted to determine the bioavailability, pharmacokinetics and safety of orally administered ORC-13661. A single ascending dose (SAD) study (30 400 mg) was followed by a multiple ascending dose (MAD) study (10-80 mg). MAD study design used an initial loading dose to achieve steady state levels followed by 11 daily dosing at 10-80 mg. Plasma samples were collected daily for the duration of the study and for up to 22 days after the last dose of ORC-13661. Safety data were collected through 46 days after the last dose. Phase 2 is a proof of concept clinical trial using a multi-site, double blind placebo-controlled design, developed as a collaboration between OHSU School of Public Health and Oricula Therapeutics LLC, has received generous funding by NIDCD and NCATS and passed FDA examination. Phase 2 participants will be patients with NTM treated with IV-amikacin infusion 2-3 times weekly for up to 3-months, and be randomized to placebo or low- and high-dosing arms. Baseline and follow-up testing will occur (± 5 and ~28 days post-treatment) using a series of hearing metrics (audiometry, otoacoustic emissions, tympanometry, grading scales, HearX) and surveys (TOMI, modified-HHIA, ABC balance scale). Primary hearing outcomes will be determined using the ASHA-shift criterion, and secondary analyses will include changes from baseline for all other hearing and balance metrics and surveys.

Results: Phase 1 establish that ORC-13661 was safe and drug exposure was dose proportional. Timing of maximum drug levels (Tmax) ranged from 4-6 hours and the drug was found to have relatively long with a half-life (t¬Ω) of 66-81 hrs. There were no serious treatment-emergent adverse events (TEAEs), or

subject discontinuations due to a TEAE in this study. Hearing, monitored by pure tone audiograms up to 16 kHz, showed no consistent changes from baseline in any of the groups including the placebo group, indicating that ORC-13661 does not cause hearing loss under these conditions. Phase 2 data collection is currently scheduled to begin in April 2024.

Conclusions: ORC-13661 is a first in class new drug developed for prevention of inner ear toxicity due to aminoglycosides. Successful completion of this clinical development program will provide a clear path toward mitigating communication deficits in patient populations requiring repeated treatment with IV-aminoglycosides.

Category: Diagnostic Audiology / Otology

Poster #: 038

Monitoring Audiological Outcomes in Otitis Media via Mobile Testing

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Objectives: Otitis Media with Effusion (OME) can persist for days to months and is often accompanied by a fluctuating conductive hearing loss (CHL). OME typically affects very young children at ages where behavioral assessment and monitoring of hearing can be challenging. Further, we are not able to predict from current assessment procedures whether an effusion will persist or clear. As such, it is not well understood if and how OME characteristics and associated CHL change over the course of an episode of OME. Understanding this could help identify objective prognostic indicators of OME and hearing status to improve the diagnosis and management of OME. Wideband Acoustic Immittance (WAI) is a measure of middle-ear mechanics that has shown strong potential as a non-invasive and objective diagnostic tool for OME and related CHL. This study utilizes WAI alongside traditional audiological measures to monitor and characterize OME and its associated CHL over time. To achieve this, longitudinal monitoring of children with OME was conducted using a mobile research van that allowed for weekly visits with participants by reducing barriers related to transportation with a goal of increasing representation of diverse patient populations.

Design: Children with a diagnosis of OME by a Boys Town National Research Hospital otolaryngologist were invited to participate in the study regardless of management strategy (tube placement, watchful waiting, or antibiotics). Participants completed an initial hearing assessment visit in our laboratory promptly following diagnosis of OME. Weekly visits continued for at least 4 weeks using the mobile research van, unless tubes were placed prior to this endpoint. Additional visits were completed if the episode continued to persist past 4 weeks and the family consented to additional visits. At the initial visit, participants underwent a comprehensive testing protocol, including behavioral audiometry, WAI, tympanometry, and otoacoustic emission (OAE) testing. Middle-ear status was monitored weekly in the research van using WAI, tympanometry, and OAEs. Behavioral testing was repeated if a change in middle-

ear status occurred. A change in WAI was characterized based on a WAI absorbance consistent with a change in effusion volume.

Results: Data collection is ongoing, with weekly monitoring completed in 4 children and 3 age matched controls thus far. Our analyses will evaluate whether audiologic profiles of each child (audiometry, OAEs, tympanometry, and WAI) suggest stable or variable effusion and hearing status over time across visits. We further plan to explore whether certain characteristics of an episode of OME or WAI at the initial visit are suggestive of the trajectory and prognosis of the episode. Finally, we plan to compare WAI data at the initial visit with effusions that successfully clear via non-surgical intervention and those with persistent effusions to determine if there are WAI features that predict failure to clear.

Conclusions: The results of this work will improve our understanding of the trajectory of OME and its associated CHL as well as the prognostic value of WAI. Improvements in the diagnosis and prognosis of OME and its related hearing loss will help refine clinical protocols and improve auditory outcomes for children.

Category: Diagnostic Audiology / Otology

Poster #: 039

Thinking Outside the Box: Characterizing Cochlear Aging Beyond the Audiogram

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Objectives: With a rapidly aging population and groundbreaking treatments for hearing loss on the horizon, it is time to reimagine our tools for diagnosing age-related hearing loss (ARHL). Our current diagnostic processes present at least two major problems. First, they are not conducive to early identification of ARHL. Age-related auditory change can occur decades before most individuals seek or receive treatment. Second, all ARHL is lumped into a single clinical category - "sensorineural" - when there are at least four etiological categories driving it. In this talk, we will present data collected across multiple studies within our laboratory that underscore these problems and take an initial step towards enhanced protocols for diagnosing ARHL.

Design: Data will be presented from individuals across the adult lifespan collected in several cross-sectional studies from our laboratory. Importantly, all participants included in the studies were carefully selected to have little to no hearing loss on the conventional audiogram. The studies used novel combinations of measures (including multiple types of otoacoustic emissions, extended high frequency behavioral thresholds, and metrics of cochlear and behavioral tuning) assessed out to the highest frequencies of human hearing. These measures were selected to non-invasively identify the first signs of auditory decline and to ascertain the biophysical mechanisms driving this decline.

Results: Several key findings emerge from our data. First, age-related changes in hearing are apparent as early as the fourth decade of life (30-39 years of age) and can precede shifts in standard audiometric threshold(s). Second, age-related auditory changes are multifaceted and highlight the inadequacy of relying on behavioral thresholds measured at conventional frequencies for diagnosis. Third, auditory

aging is variable across individuals. This underscores the need for personalized diagnostic and treatment approaches for ARHL.

Conclusions: These insights compel a reevaluation of current diagnostic practices in audiology, particularly for ARHL. Our findings demonstrate a significant need for research into the mechanisms of auditory aging and stress the need to adopt comprehensive diagnostic protocols that extend beyond traditional audiometric thresholds.

Category: Diagnostic Audiology / Otology

Poster #: 040

Validation of Bone-Conduction Measurements Made with Audiometer Designed for Telehealth

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Objectives: Telehealth and boothless technologies have the potential to increase access to hearing healthcare for underserved communities, especially in rural areas. Measuring bone-conduction thresholds is important for the differential diagnosis of ear disease but normally requires a sound-treated booth to ensure a quiet environment. The Wireless Automated Hearing Test System (WAHTS) has earcups designed to provide high passive noise attenuation that is on par with that of a single-wall sound booth. The objective of this study was to compare the bone-conduction measurements obtained using a new prototype WAHTS designed with a bone oscillator (WAHTS-BC) to thresholds obtained with a commercial diagnostic audiometer within a sound-treated booth.

Design: 58 ears (29 subjects) with either normal (N=11), sensorineural (N=26), unilateral conductive (N=2), bilateral conductive (N=7) or mixed (N=12) hearing loss were recruited. Each subject was tested twice in the booth with a commercial audiometer, once with the prototype inside the booth, and once with the prototype outside the booth. The bone oscillator was located at the forehead for both devices. Measurements were made with no masking for all ears and frequencies (250 Hz ‚Äì 6000 Hz), and then with masking on the right or left ear, when needed.

Results: Test-retest variability of the bone conduction measurements for each device was comparable across frequencies and 90% of measurements for either device were within +/-10 dB. Similarly 90% of all differences between the average of the two measurements obtained with the commercial audiometer and the average of the two measurements obtained with the prototype were also within +/-10 dB.

Conclusions: The prototype boothless diagnostic audiometer with integrated noise attenuation can measure hearing thresholds outside the booth with reliability that is on par with existing clinical devices, assuming acceptable ambient noise levels given the known attenuation of the transducer. The results of this study lay the foundation for a study evaluating the prototype in a telehealth application in Alaska.

Category: Diagnostic Audiology / Otology

Poster #: 041

Are We There Yet? Omitting Data from the Beginning of a Staircase

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Objectives: Up-and-down staircase procedures are commonly used to measure hearing ability in research and clinical audiology. Designing staircase procedures requires many decisions with little more than heuristics and tradition for guidance. One example is the number of trials, or stimulus-response pairs, omitted at the beginning of the staircase as it converges. It is customary to omit trials until one (e.g., pure-tone audiometry) to six (e.g., laboratory psychophysics) reversals in the direction of sequential stimulus level changes. However, the occurrence of a reversal is a stochastic process influenced by factors unrelated to the validity of early trials. The number of early trials to omit can be determined by calculating the rate of convergence directly. In this study, the reversal counting method was evaluated relative to the rate of convergence of the staircase.

Design: Simulations were used to evaluate staircase convergence during the first six reversals as a function of step size and starting level. Listener responses were simulated for a yes-no task with a cumulative normal psychometric function. Total variation distance was used to quantify the convergence of the staircase after each reversal.

Results: The stimulus level at which early reversals were observed was highly dependent on the starting level selected by the experimenter, making reversals a poor indicator of the convergence of a staircase. The number of trials per reversal decreased with increasing step size. Total variation distance decreased with the number of reversals, consistent with the number of trials presented.

Conclusions: Counting reversals is an unreliable method to determine the number of trials to omit from the beginning of a staircase procedure. Staircase designs can be improved by calculating the number of trials to omit directly from the rate of convergence. This approach can improve efficiency and reduce variability in measurement procedures used in clinical and research audiology.

Category: Diagnostic Audiology / Otology

Poster #: 042

Influence of COVID-19 and Prior Ear Infections on DPOAE Levels

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Laura Dreisbach, *PhD*, *San Diego State University*, *San Diego*, *California*

Objectives: Viruses and ear infections can have adverse effects on auditory function. The purpose of this study was to explore distortion product otoacoustic emission (DPOAE) levels across an extended frequency bandwidth in those testing positive or negative for COVID-19 with and without prior ear infections.

Design: We enrolled 108 college adults who did (n=63) and did not (n=45) report testing positive for COVID-19. A health questionnaire was administered and of those reporting positive COVID-19 results, 38 had prior ear infections while 26 of those reporting negative COVID-19 results had prior ear infections. An audiological test battery was conducted including both subjective and objective tests of peripheral and central auditory function. This included otoscopy, tympanometry, a screening contralateral acoustic reflex at 1 kHz, conventional and extended high-frequency (EHF) hearing thresholds (0.25-16 kHz), DPOAEs measured at conventional (1- 8 kHz) and EHFs (9-16 kHz) with stimulus levels (L1/L2) of 65/55 dB SPL and a ratio (f2/f1) of 1.22, click- and speech-evoked auditory brainstem responses (ABRs), speech testing in quiet and noise (QuickSIN), and a screening battery for central auditory processing disorder (CAPD). The 1-Minute Noise Exposure Screen and the modified Amsterdam Inventory for Auditory Disability (mAIAD) questionnaires were administered. Advanced in-ear calibration was used to collect the DPOAE data and middle ear reflectance values were obtained.

Results: Hearing thresholds were<20 dB HL for 0.25-8 kHz for all participants. Essentially no differences existed for EHF hearing thresholds, ABRs, QuickSIN, CAPD tests, and the questionnaires between the groups. DPOAE levels exhibited differences between the COVID-19 groups where responses were slightly larger in those testing positive for COVID-19 between 5-9 kHz, but reduced at frequencies >9 kHz. For those reporting prior ear infections, regardless of COVID-19 history, DPOAE levels were reduced between 6-12 kHz and comparable at other frequencies compared to those without prior ear infections. However, for those with prior ear infections and positive for COVID-19, larger DPOAE levels from 4-10 kHz with reductions >10 kHz were found compared to those negative for COVID-19. For those without prior ear infections and positive for COVID-19, results exhibited slightly larger DPOAE levels from 6-10 kHz with reductions >10 kHz compared to those negative for COVID-19. Middle ear reflectance will be reported for all groups to further examine the influence of middle ear properties on DPOAE levels.

Conclusions: DPOAE levels are generally larger at conventional frequencies and reduced at EHFs for those positive for COVID-19 compared to those negative for COVID-19. This same pattern persists in those with and without prior ear infections testing positive for COVID-19. However, for those with prior ear infections, regardless of COVID-19 history, DPOAE levels are similar or reduced (6-12 kHz) compared to those without prior ear infections. Results suggest more than an influence of middle ear function on DPOAE levels and warrants further exploration. Overall, these results can inform clinical practice when evaluating those who have tested positive for COVID-19 and with and without prior ear infections.

Category: Diagnostic Audiology / Otology

Poster #: 043 **Mentored Student Research Poster Award**

Patient Perspectives on Living with Pain Hyperacusis

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Objectives: Hyperacusis is a multifaceted auditory disorder that is characterized by reduced tolerance to sounds that do not bother most people. The quality and severity of hyperacusis symptoms vary from person-to-person. Some individuals perceive moderate intensity sounds as uncomfortably loud (loudness hyperacusis), whereas others report physical pain in response to everyday sounds (pain hyperacusis). Although the pain hyperacusis subtype is acknowledged in the literature, its prevalence, characteristics, and underlying mechanisms are poorly understood. In this qualitative study, we sought to characterize the lived experience of pain hyperacusis from the patient perspective.

Design: We invited 40 adults who experience pain hyperacusis to participate in a one-hour virtual focus group and two follow-up surveys. During the focus group, participants provided open-ended responses to two prompts that probed the characteristics of their sound-induced pain and additional symptoms related to hyperacusis. After the focus group, the research team generated 92 statements that were representative of all the open-ended responses. Participants were then invited to complete two online surveys. The first survey (Rating Survey) asked participants to rate how well each of the 92 statements applied to their own lives using a 5-point Likert scale. The second survey (Sorting Survey) asked participants to sort the 92 statements into categories that they felt were thematically similar. Data were analyzed using multidimensional scaling and hierarchical cluster analyses to identify sub-categories of experiences within the larger dataset.

Results: Participants reported a variety of characteristics, behaviors, and symptoms associated with their sound-induced pain. Cluster analyses revealed 17 distinct themes in the data. Clusters that described the effects of pain hyperacusis on quality of life and relationships were rated consistently high across participants. The top three most highly rated clusters described constructs related to isolation and reduced physical activity, lack of empathy or support from others, and control and avoidance behaviors. In contrast to effects on quality of life, the specific characteristics of the sound-induced pain tended to vary across participants. Although 92% of participants reported pain in or near their ears, many also reported sound-related pain in the head (side: 57%; back: 42%; front: 30%), neck (53%), or body (46%). The pain was often neuropathic in nature, with most participants reporting burning (80%), stabbing (77%), throbbing (73%), and pinching (53%) sensations. It was noted that all participants' symptoms become worse the longer they are exposed to sound (100%), and 84% indicated that white noise worsens their symptoms.

Conclusions: These results suggest that although the characteristics of sound-induced pain (e.g., type, severity, laterality) vary from person-to-person, the negative impact of pain hyperacusis on quality of life is highly consistent. Persistent isolation and low physical activity could have cascading negative effects on physical health that warrant further investigation in this population. Moreover, the high incidence of neuropathic-like symptoms suggests that appropriate management strategies for pain hyperacusis may differ from other subtypes of sound sensitivity such as loudness hyperacusis or misophonia.

Category: Diagnostic Audiology / Otology

Poster #: 044 **T35 Research Trainee Poster**

Platinum-Based Chemotherapy Ototoxicity: Exploring Comprehensive Measures Beyond the Audiogram

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Objectives: The objective of this study was to determine which audiological measures best predict the onset or worsening of self-reported tinnitus and the ability to understand speech in noise following treatment with platinum-based chemotherapy. We predicted that threshold shifts near each person's high-frequency hearing limit would prove to be more useful than pure tone audiometry for identifying ototoxic-induced tinnitus and speech understanding problems, particularly when combined with physiological measures of outer hair cell function (distortion-product otoacoustic emissions, DPOAEs) and acoustic reflex growth (wideband middle ear muscle reflex, MEMR).

Design: This study followed a longitudinal design in patients each served as their own control. Patients treated with cisplatin, carboplatin, or oxaliplatin at the Portland VA underwent baseline testing before initiation of cancer treatment. They were also scheduled for follow-up appointments that occurred about 30 days and one year after their baseline visit. Ototoxicity was monitored using conventional and extended-high frequency audiometry, allowing for the sensitive range for ototoxicity (SRO) to be measured. Additionally, we characterized ototoxicity using questionnaires and measures of speech perception to determine the impact of ototoxicity on auditory perception. Physiological measures included wideband tympanometry, amplitude growth of the MEMR, and DPOAEs. In order to focus these preliminary analyses on cochleotoxic effects, data was evaluated for visits that indicated normal middle ear function and for which the majority of measures could be obtained.

Results: We employed mixed-effects logistic regression to analyze how individuals perceived tinnitus and speech, using subject-specific conventional audiometry, SRO, and physiological measures. Additionally, results from the digit symbol coding task of the Wechsler Adult Intelligence Scale version III, as well as a follow-up visit after one year, were included in the model as supplementary indicators to distinguish between cochleotoxicity and the cognitive effects of chemotherapy treatment.Preliminary findings suggest that individuals treated with cisplatin, particularly those younger than 50 years with good pre-treatment hearing, reported high rates of ototoxic-induced tinnitus and experienced declines in speech understanding. Notably, many participants undergoing platinum-based treatment did not exhibit significant audiometric threshold shifts within the standard frequency range (0.25 - 8 kHz). However, a considerable number reported either worsened tinnitus or difficulties in understanding speech, impacting their quality of life as self-reported.Among the measures, significant changes in the SRO were the best predictors of self-reported tinnitus, hearing difficulties, and spatial release from masking (SRM) scores. These findings underscore the importance of alternative measures beyond traditional audiometry in capturing the impact of ototoxicity on individuals' subjective experiences and quality of life.

Conclusions: The study's results underscore the importance of regular ototoxicity management follow-up appointments for individuals undergoing treatment with platinum-based chemotherapeutic drugs. It is crucial to establish baseline measurements and sustain care even after chemotherapy ends. During the

monitoring appoints, it is vital for speech-in-noise assessments and patient-reported outcomes to be integrated into the appointment, preventing the inadvertent oversight of patients experiencing ototoxic effects. Furthermore, two additional tests, SRO and SRM, are proposed as supplementary measures that can be readily incorporated into an ototoxicity management protocol for healthcare providers.

Category: Diagnostic Audiology / Otology

Poster #: 045

Experiences of Patients with Hidden Hearing Loss Seeking Hearing Healthcare

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Objectives: 5-10% of adults seeking hearing healthcare for significant hearing concerns will have audiometric thresholds within normal limits. A recent survey asking audiologists how they handle these patients found that most patients are sent on their way without an explanation for their concerns and minimal, if any, guidance or treatment recommendations. To date, our knowledge about the interactions between such patients and their providers are from the providers' perspectives. There has been no research asking patients what they are experiencing during their appointment from their own perspective. In this study, we explored what themes emerged when individuals with undiagnosed hearing concerns discussed their experiences when seeking hearing healthcare.

Design: We conducted semi-structured interviews with 15 adults. To participate in the study, participants had to be ≥ 18 years of age, have complaints of hearing loss or hearing difficulties, have sought a professional hearing evaluation due to a hearing concern, and have hearing test results that do not indicate a hearing loss. We asked participants to first share their story about getting their hearing tested and then answer follow-up questions regarding where they were tested and if the provider gave any referrals or treatment recommendations. We used thematic analysis on the interview transcripts to uncover common themes across participants' experiences. During the analysis we enaged in rigorous verification procedures to ensure our results were valid and reliable.

Results: The interviews revealed three salient themes: (1) dismissive hearing healthcare providers - a scenario when participants felt their provider downplayed or disregarded their concerns; (2) misalignment of patient concerns and assessment protocols - a discrepancy between what the healthcare providers are assessing and the primary complaint of the patient; and (3) doctor shopping - a behavior where patients seek out more than one provider for a diagnosis or treatment.

Conclusions: Understanding what someone with hidden hearing loss experiences when seeking hearing healthcare is crucial for improving care. Our findings indicated hearing healthcare providers may not be following ASHA and AAA-recommended guidelines for best practice and may be relying too heavily on audiometric results for their recommendations. All three themes revealed the need for patient-centered hearing health care that follows a biopsychosocial model.

ELECTROPHYSIOLOGIC RESPONSES

Category: Electrophysiologic Responses

Poster #: 046 **Mentored Student Research Poster Award**

Cortical Auditory Processing and Speech Perception from Childhood to Adolescence

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Objectives: Between birth and young adulthood, there is a gradual maturation in speech recognition skills that stems, at least partially, from structural and functional changes in the central auditory system. Cortical auditory evoked potentials (CAEPs) provide a rich source of information about the central nervous system pathways and structures along the auditory pathway. Specifically, amplitudes and latencies of obligatory components (P1, N1, and P2) provide an important index of auditory maturation during development. For example, it has been reported that with age, N1 amplitude increases and N1 latency decreases. However, how the maturation of cortical auditory processing is associated with the development of speech recognition skills remains unclear. To investigate how maturational signatures of cortical auditory evoked potential amplitudes and latencies are associated with speech perception skills, we assess cortical auditory evoked potentials in response to speech stimuli in participants encompassing the developmental period across childhood and adolescence.

Design: Participants span the age range of 5-17 years. Behavioral speech perception in quiet was evaluated using the Children's Realistic Index for Speech Perception (CRISP) test. Cortical auditory evoked potentials were elicited in quiet using low and high-frequency/m/ and /s/ speech sounds. Cortical auditory obligatory responses (N1 and P2) were measured in response to speech sounds to assess the maturation of speech detection (N1), categorization (P2), and differentiation (differences between /m/ and /s/ cortical responses).

Results: Data collection and analyses are ongoing. As reported in previous studies, analyses from cortical auditory evoked potentials data acquired thus far (n=24) indicate a maturation effect. Specifically, we observe that N1 amplitude increases and N1 latency decreases with age. Further, there is a trend in associations between the neural and behavioral measures, such that an increase in N1 amplitude and a decrease in N1 latency are positively associated with increased speech perception. These preliminary results show that among children, cortical processing for speech detection matures with age and is associated with improvement in speech perception skills. We anticipate that as the study progresses, we will uncover more details about the maturation of processes underlying speech categorization and differentiation and their associations with speech perception skills.

Conclusions: Our findings shed light on the complex interplay between age and cortical auditory maturation and how that relates to speech perception abilities. As we continue to analyze the data, we anticipate a more comprehensive understanding of the mechanisms underlying auditory development,

which can ultimately lead to improved strategies for optimizing communication skills in individuals at different stages of auditory development.[Work supported by NIH-NIDCD R01 DC019511 to R.Y. Litovsky].

Category: Electrophysiologic Responses

Poster #: 047

Auditory Challenges in Down Syndrome: Insights from Cortical Evoked Potentials

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Objectives: Down syndrome (DS) is the most common chromosomal condition affecting multiple systems in the body. Individuals with DS have high rates of hearing loss compared to individuals without DS. Additionally, individuals with DS show anatomical and functional differences related to the central auditory system that may contribute to difficulties in processing auditory information; this could interact with hearing loss to further alter their ability to use auditory information effectively in everyday life. Indeed, previous physiological studies using auditory evoked potentials showed evidence that individuals with DS have difficulties in processing auditory stimuli. However, little is known about cortical auditory processing among individuals with DS, nor whether alterations in auditory cortical processing in individuals with DS are associated with their auditory perceptual abilities. We hypothesize that young adults with DS will show delays in cortical auditory processing as compared to the control group. Further, auditory processing delays in young adults with DS will be associated with reduced speech perception.

Design: This study focuses on young adults with DS (aged 18-24 years) and age-matched neurotypical controls with no hearing loss. Cortical auditory obligatory responses to low and high-frequency speech sounds (/m/ and /s/) are measured to assess speech detection (N1), categorization (P2), and differentiation (differences between /m/ and /s/ cortical responses) across the two participant groups. Pure tone air conduction audiometry is used to assess the presence or absence of hearing loss (type and degree), while speech reception thresholds (SRTs) are measured using the Children's Realistic Index for Speech Perception (CRISP) test.

Results: The study is currently ongoing. Initial findings showed a higher occurrence of high-frequency hearing loss in at least one ear among individuals with Down syndrome. Preliminary analyses revealed a statistical trend toward smaller N1 amplitudes and larger P2 amplitudes in individuals with DS compared to controls. This suggests immature speech detection and an enhanced need for top-down control to categorize speech sounds in individuals with DS. Notably, N1 peak amplitudes were larger for /m/ than /s/ in control adults without DS, but this distinction was not observed in adults with DS. This may indicate differences in discrimination of low- vs. high-frequency sounds at the speech detection level. In addition, individuals with DS have higher SRTs as compared to controls. As we continue to acquire more data, we will examine associations between the maturation of cortical auditory processing with SRTs and hearing loss.

Conclusions: Our preliminary analyses suggest possible cortical speech processing delays in young adults with DS. With further data acquisition, we anticipate a more comprehensive understanding of the mechanisms underlying auditory cortical processing among young adults with DS and associations with hearing loss and speech perception. Our study is positioned to contribute to the sparse literature concerning auditory processing in individuals with DS and provide insights into possible strategies for supporting speech perception in young adults with Down syndrome.

Category: Electrophysiologic Responses

Poster #: 048

Predictive Ability and Variability of Area Ratio Versus Amplitude Ratio Electrocochleography (ECochG) Measures in Patients with Endolymphatic Hydrops

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Objectives: Patients with hearing instability disorders, including Meniere's disease (MD), autoimmune inner ear disease, and sudden sensorineural hearing loss, have been shown to have endolymphatic hydrops (EH). The increase of endolymphatic volume can result in audiovestibular symptoms including hearing loss, aural fullness, tinnitus, and dizziness. ECochG is the primary test used by audiologist in the differential diagnosis of MD/EH; however, the sensitivity and specificity of this test are relatively low. The goal of this study is to compare the sensitivity and specificity of summating and action potential (SP and AP, respectively) area ratios and amplitude ratios in patients with and without EH that has been verified by contrast-enhanced delayed FLAIR MRI as well as comparing the variability of these ECochG outcome measures over time.

Design: A cohort of 21 patients (mean age, 44.4 yrs, +/-14.3; 13 males) who experience hearing fluctuations were seen for audiology evaluations and MRIs at 3-month intervals. Presence of EH was determined at each visit by review of contrast-enhanced delayed FLAIR MRI images by an experienced neuro-radiologist. Data from 168 ears across multiple study visits were included in the analysis, with 54 ears having EH present. Audiometric evaluations included pure tone hearing threshold testing and

electrocochleograms to click stimuli using Lilly TM-wick electrodes placed under otomicroscopy. When a response was present, the baseline, SPs, and APs were identified and used to calculate the SP/AP amplitude and area ratios. Mann-Whitney U tests were used to compare area and amplitude ratios in ears with and without EH. Abnormal thresholds for amplitude and area ratios were operationally defined as 0.4 and 2.0, respectively. Sensitivity and specificity indices will be determined using Receiver Operator Curves (ROC) and further investigations will determine if revised criteria can improve sensitivity and specificity to optimize identification of hydrops.

Results: Preliminary analyses suggests a significant difference in SP/AP amplitude ratios in ears with and without MRI confirmed EH ($p=0.03$). There is no significant difference in SP/AP area ratio between these groups.

Conclusions: Despite 60% of ears with MRI confirmed hydrops having a normal amplitude ratio as defined by the current definition of normal, there was a significant difference in overall mean between groups suggesting that sensitivity could be improved by modifying the normative cut off. Further directions include determining if a combination of area and amplitude ratios could improve detection of EH. Additional analyses will include comparisons of ECochG outcomes in patients with and without EH against healthy controls.

Category: Electrophysiologic Responses

Poster #: 049 **T35 Research Trainee Poster**

Perceptual Consequences of Cochlear Synaptopathy: Speech Perception with Non-Linguistic Stimuli

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Objectives: While cochlear synaptopathy is well-documented in both animal models and human temporal bones, evidence of the effects of synaptopathy on speech perception have been mixed. One explanation for the mixed findings may be that ABR wave I amplitude is a poor measure of synaptopathy, or that speech perception is not accurately measured. There is some evidence that the envelope following response (EFR) may be a better indicator of synaptopathy than ABR wave I amplitude, and that speech perception metrics that minimize linguistic cues and emphasize temporal processing may be more sensitive to synaptopathy-related deficits. As such, this is an exploratory investigation of the relationship between EFR magnitude (an indicator of synaptopathy) and performance on speech perception/temporal processing tasks in a population expected to demonstrate a wide variety of cochlear synapse numbers.

Design: In a sample varying in age and noise exposure history, we investigated the relationship between EFR magnitude and two measures of speech perception/temporal processing: 1) a nonlinguistic four-alternative forced choice task consisting of tokens of words played backwards, one of which has been distorted by adding compression and 2) a low context word level speech perception in noise test (the Words-in-Noise [WIN] test). Thirty-eight adults aged 19-50 years completed the study (19 females, 19 males). Nineteen participants were military Veterans. The EFR testing consisted of rectangular amplitude modulated (RAM) stimuli presented at carrier frequencies of 2000, 4000, and 8000 Hz with a modulation frequency of 110 Hz. Distortion product otoacoustic emissions (DPOAEs) were also measured to assess outer hair cell function, which could confound the relationship between EFR magnitude and speech perception performance.

Results: Based on non-linear relationships observed in the raw data, the relationships between EFR magnitude and performance on the speech perception/temporal processing tests were analyzed using a non-linear regression analysis that included statistical adjustment for average DPOAE level from 3-8 kHz. The results of these analyses showed no clear relationship between the nonlinguistic speech test and EFR magnitude. In contrast, for a 4 kHz EFR carrier frequency, performance on WIN list 1 improved as EFR magnitude increased, but this relationship flattened out at higher EFR magnitudes.

Conclusions: In a sample population expected to exhibit a range of degrees of synaptopathy, there was no clear relationship between EFR magnitude and performance on the nonlinguistic speech test, which suggests that this particular test is not sensitive to synaptopathy-related perceptual deficits. In contrast, performance on WIN list 1 improved as EFR magnitude increased for low EFR magnitudes and then plateaued at higher EFR magnitudes. If we assume that EFR magnitude is proportional to degree of synaptopathy, this suggests that past a certain threshold degree of synapse loss, synaptopathy has a negative impact on speech perception in noise.

Category: Electrophysiologic Responses

Poster #: 050

Parallel Auditory Brainstem Responses (pABR) Characteristics Near And Above Threshold

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Objectives: Auditory brainstem responses (ABR) are used to objectively evaluate hearing function in both research and the clinic. The parallel ABR (pABR) is a new method that speeds up testing by simultaneously presenting all frequencies in both ears. To date, only wave V of the pABR has been characterized because it has been the prominent component that reliably predicts hearing threshold - the most common application of ABR testing. But the extended analysis time windows afforded by the randomized timing of the pABR stimuli may confer additional benefits by evaluating different parts of the early auditory system pathway. Furthermore, having access to this extra information at supra- and near-threshold levels may support clinical decision making for waveforms with poorer morphology, such as broader low-frequency responses. Thus, this study aimed to evaluate the different component waves of pABR responses at a low and high level. We hypothesized that the later MLR components would aid

identifying earlier ABR wave Vs, particularly for broader lower-frequency ABRs and at near-threshold levels.

Design: Data were downloaded from an open-set repository on Dryad. This dataset included 20 normal hearing adult participants (13 females, 6 males, 1 non-identifying, ages 18-35 years) who listened to pABR stimuli (0.5, 1, 2, 4, 8 kHz in both ears) at six stimulation rates (20-120 Hz) and two intensities of 51 and 81 dB peSPL (~30-40 and 60-70 dB nHL respectively). ABR and MLR waves were visually chosen and analyzed for their presence, latency, and amplitude at two intensities. Peak picking consistency across two markers was analyzed using the intraclass correlation type III coefficient. Peak amplitude and latencies were analyzed using linear mixed-effects modeling with participant and peak marker as random effects.

Results: Chosen ABR peaks were reliable across two markers and showed wave Vs at both near-and supra-threshold levels, whereas waves I and III were mainly identifiable for mid/high frequency responses for the supra-threshold level and at low/mid stimulation rates. Later MLR responses were visible at both levels and will be further characterized. Preliminary visualization of responses suggest that the MLR may be useful for identifying ABR wave V peaks for individual participant waveforms where wave V was not as prominent.

Conclusions: pABR testing at a suprathreshold level of 81 dB peSPL and near-threshold level of 51 dB peSPL provides information about multiple early stages of auditory processing while using a moderate/low intensity. In addition, having access to viewing the MLR during pABR testing may provide an additional tool for audiologists when evaluating wave presence near threshold.

Category: Electrophysiologic Responses

Poster #: 051

Resting EEG Indicators of the Development of Listening-Related Fatigue

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Objectives: People with hearing loss often exert listening effort in order to succeed at recognizing speech, drawing on limited-capacity attentional and/or working memory resources to do so. Sustained listening effort is theorized to lead to mental fatigue, a subjective feeling of exhaustion accompanied by reduced cognitive functioning. Listening-related fatigue has been measured primarily with self-report questionnaires, with few objective measures available. However, in the broader literature increases in neural oscillatory power are known as indicators of mental fatigue. In a recent study, such power increases in the alpha (8-12 Hz) and theta (4-8 Hz) frequency bands were observed during performance of a challenging listening task by middle-aged adults. The goal of the current study was to examine the potential of similar measures collected from the resting electroencephalogram (EEG) before and after a challenging listening task in older adults. It was hypothesized that post-task spectral power would be greater than pre-task power in both frequency bands.

Design: Twenty older adults (M = 67.85 years, SD = 7.5) with a range of hearing abilities (high-frequency (1, 2, and 4 kHz) pure-tone average M = 29.04 dB HL, SD = 13.26) participated. In an approximately hour-long listening task, participants identified words from spoken sentences presented at a comfortable listening level at a range of SNRs that were set relative to an individualized SNR targeting each participant's speech recognition threshold. Before and after the listening task, resting EEG was collected for two minutes in an eyes-closed and eyes-open condition, which were presented in random order, and participants also self-reported their level of general fatigue using a visual-analogue scale. Alpha power was quantified as mean power from a set of posterior electrodes and theta power as mean power from a set of frontal-midline electrodes.

Results: A numerical trend for the expected increase in power following the listening task was observed for all measures of spectral power except for theta in the eyes-closed condition. However, this difference was significant only for alpha power in the eyes open condition [$t(19) = -2.428$, SE = 1.556, $p = .013$]. Self-reported fatigue also increased from pre- to post-task [$t(19) = 5.420$, SE = 0.315, $p < .001$], confirming that performance of the listening task induced the subjective experience of mental fatigue.

Conclusions: The current findings indicate that oscillatory power collected from resting EEG before and after a listening task has potential to serve as an objective, brain-based indicator of listening-related fatigue in older adults, with alpha power quantified from eyes-open EEG as the most promising of the tested measures.

Category: Electrophysiologic Responses

Poster #: 052

Assessment of the Human Medial Olivocochlear Reflex Using the Cochlear Microphonic

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Objectives: This study tests the hypothesis that the amplitude of the human cochlear microphonic (CM) will increase in response to low-level (e.g., 50 dB SPL) contralateral acoustic stimulation (CAS), consistent with an increase in outer hair cell (OHC) conductance observed when the medial olivocochlear (MOC) reflex is elicited in laboratory animals.

Design: Two experiments were conducted in young adults with normal hearing, where a total of 24 participants (6 males) were included. The CM was elicited by a 500-Hz sinusoid (Experiment 1), or by a sweep that included frequencies between 125-6000 Hz (Experiment 2). Both probes were 90 dB SPL and CM responses were recorded in the presence or absence of CAS. The CM was measured using a custom tympanic membrane electrode and the state of arousal was maintained by engaging participants with a vibrotactile task.

Results: Experiment 1 (500-Hz probe): In most (9/10) subjects, CM amplitude increased for CAS levels of 45 and 55 dB SPL. Conversely, CM amplitude decreased for CAS levels of 65 and 75 dB, consistent with eliciting the middle ear muscle (MEM) reflex. Experiment 2 (frequency swept tone): Significant increases in CM amplitude, typically on the order of 1-2 dB, were observed for most participants from 300-2000 Hz, where the size and consistency of these effects depended on participant, probe frequency, and sweep

direction of the probe. CAS-related phase lags were also observed, consistent with CM-based MOC studies in laboratory animals.

Conclusions: A CM-based test of the MOC reflex may facilitate detection of MEM effects and the assessment of adults with cochlear hearing loss who often have measurable CM responses. Effects of CAS on the CM likely originate from MOC-related changes in the conductance of OHCs located in the basal tail of the traveling wave. Thus, MOC effects on the CM are complementary to those observed for otoacoustic emissions, which are sensitive to changes in the motility of OHCs located near the peak region of the traveling wave.

Category: Electrophysiologic Responses

Poster #: 053

Neural Representation of Noisy and Reverberant Speech

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Objectives: Understanding speech in the presence of background noise can be very difficult, especially when it occurs in enclosed reverberant spaces. Variability in performance is likely due to a combination of factors including room and noise characteristics. A physiological measurement of noise and reverberation effects may aid in our understanding of the performance variability across individuals in complex listening environments. The purpose of this study was to determine how neural encoding is differentially affected by reverberation, noise masking, and the combination of the two. We hypothesized that increasingly complex environmental interferences would result in weaker electrophysiological responses.

Design: The cortical N1 and cognitive P3 auditory evoked potentials were obtained from adults (18-40 years of age) with normal hearing thresholds. A complex oddball paradigm consisting of multiple consonant-vowel targets and non-targets was used. Four consonants (/b/, /g/, /v, /θ/) and four vowels (/ɑ/, /u/, /i/, /ə/) spoken by eight talkers (four male and four female) were used. These tokens were then prepended with a /di/ syllable to create 128 two-syllable test tokens that contained realistic masking in reverberant contexts. These test tokens were presented in four conditions: (1) anechoic, (2) background babble, (3) reverberation, and (4) background babble + reverberation. Four randomized runs (one run with each consonant as the target) for each condition were completed in which participants were instructed to press a button whenever they heard the target consonant.

Results: Preliminary analysis demonstrated that both background noise and reverberation weakened the neural responses. Strength of the effects of reverberation alone and noise masking alone will be shown and discussed relative to the effects caused by the combination of noise masking and reverberation.

Conclusions: Real-world listening environments rarely contain noise and reverberation in isolation. This study determined the separate and combined effects of noise and reverberation on neural encoding to

help explain the variability in speech intelligibility among listeners in active listening contexts. (This study was supported by NIH-NIDCD R01DC015240.)

Category: Electrophysiologic Responses

Poster #: 054

Evaluation of Efferent Unmasking Using Cortical Auditory Evoked Potentials

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Objectives: Animal studies demonstrate that the auditory efferent system provides unmasking, by increasing the signal-to-noise ratio (SNR), at the level of the auditory nerve. However, evidence for unmasking in humans in limited. One reason for this may be due to the traditional approach in which otoacoustic emissions, a pre-neural measure, are used to assay the MOCR in humans. Cortical auditory evoked potentials may be advantageous in studying the MOCR as they depend on input from the auditory nerve and are sensitive to SNR. The first objective was to measure the effect of efferent activation on the late-latency response (LLR) for a tone in quiet. It was hypothesized that the LLR latencies would increase and amplitudes decrease due to reduced cochlear output and a reduced SNR at the auditory nerve. The second objective was to measure the effect of efferent activation on the LLR for a tone in noise. It was hypothesized that the LLR latencies would decrease and amplitudes increase due to efferent unmasking.

Design: Fifty normal-hearing adults participated in the study. The LLR was measured in response to 1-kHz, 60-dB SPL tone bursts presented with and without 60-dB SPL broadband noise presented to the contralateral ear. The contralateral noise served to active the medial-olivocochlear reflex (MOCR). For the first part of the study, the LLR was measured for a tone in quiet (high SNR). For the second part of the study, the LLR was measured for a tone in noise. Three noise levels were used to yield SNRs of 5 dB, 15 dB, and 25 dB. In addition to the electrophysiologic measured, efferent-induced changes to transient-evoked otoacoustic emission (TEOAE) levels and 1-kHz behavioral thresholds (in quiet) were measured.

Results: Activation of the MOCR did not have a statistically significant effect on LLR latencies or amplitudes for the tone in quiet. When the LLR was evoked for a tone in noise, MOCR activation had a statistically significant effect on LLR P1 and N1 latencies, and P1-N1 and N1-P2 inter-amplitudes. Latencies decreased upon MOCR activation and amplitude increased. SNR also had a statistically significant effect on latencies and amplitudes. There was no interaction between SNR and MOCR activation. MOCR activation also had a significant effect on both TEOAE levels and behavioral thresholds. TEOAE level was reduced and behavioral thresholds worsened upon MOCR activation. There was no correlation between the pre-neural, neural, and behavioral metrics of MOCR strength.

Conclusions: The finding of reduced LLR latencies and increased LLR amplitudes for a tone in noise upon MOCR activation suggests MOCR-induced SNR enhancement (i.e., unmasking). For a tone in quiet, there was no significant effect of MOCR activation on either LLR latencies or amplitudes. This may be due to central gain compensation for reduced cochlear output upon MOCR activation. The lack of correlation

between the various MOCR metrics may suggest that each provides different information concerning MOCR function.

Category: Electrophysiologic Responses

Poster #: 055

Time-Variance of the Medial-Olivocochlear Reflex in Otoacoustic-Emission Assays

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Objectives: Several common hypotheses surround the role of the medial-olivocochlear reflex (MOCR) in human hearing. One is that individuals with a stronger MOCR (as assayed using otoacoustic emissions; OAEs) perform better when listening in noise. A second is that individuals with a stronger MOCR are more resistant to noise induced hearing loss (NIHL). Testing these hypotheses necessarily requires an accurate estimate of an individual's MOCR strength. Traditionally, MOCR strength is estimated as the change in OAE level between MOCR-on and MOCR-off conditions, upon the conclusion of time-synchronous averaging. This assumes the OAE-based MOCR estimate is time-invariant. The objective of this study was to test the assumption of MOCR time-invariance when using a typical OAE-based assay designed to isolate the fast-MOCR component.

Design: Transient evoked (TE) OAEs were measured with and without activation of the MOCR by contralateral noise in 97 normal-hearing adults. Contralateral conditions alternated every 10 seconds across a measurement duration of 260 seconds (130 seconds for each condition). For each condition, TEOAE and noise levels were calculated using a running average spanning a subset of the collected data over a time course of 0 to 60 seconds. The MOCR-induced TEOAE level shift was calculated after each subsequent average. The analysis window was then advanced by 10 seconds and metrics were recalculated. This process repeated 15 times. Metrics were also calculated following random, repeated resampling of the full data set. The resampling process was expected to account for any temporal dependence imposed on the original data sets and yield a distribution of each subject's MOCR strength. Distributions were compared between the time-shifted and resampled data sets.

Results: The estimated MOCR strength for each subject varied across the different time-shifted subsets. Variability, quantified as the width of the 0.5 - 99.5% confidence interval, decreased as SNR increased through approximately 25 dB. However, the variance in the estimated MOCR strength meant that subjects could not be reliably ranked based on any single measure of their MOCR strength, even when SNRs exceeded 18 dB. Upon random, repeated resampling, the variability increased beyond that for the time-shifted data.

Conclusions: Results demonstrate that the MOCR-induced OAE level shift is not time-invariant. Consequently, an estimate of MOCR strength based on a single measure is likely inaccurate. The exact source(s) of MOCR time-variance are not currently known. Sequential time-shifting of the raw data and repeated, random resampling provide alternative approaches to estimating an individual's MOCR strength as both yield a distribution of the response from which the central tendency can be derived.

Resampling is expected to yield a more accurate distribution of an individual's MOCR strength as each estimate is derived from samples spanning the measurement duration.

HEARING LOSS / REHABILITATION

Category: Hearing Loss / Rehabilitation

Poster #: 056

Hearing Loss and Experience of Unmet Care Need Consequences

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Objectives: Objectives: Inability to complete activities of daily living (ADLs) and instrumental activities of daily living (IADLs) may contribute to unsafe living conditions and decreased quality of life. Previous work has suggested that hearing loss is associated with difficulty ADLs and IADLs. However, there is a paucity of data focused on associations between hearing loss and experience of the consequences related to poor ADL/IADL-related functioning (e.g. inability to leave the house, going without hot meals, soiling oneself, etc.). The objective of this study was to explore the association between hearing loss and experience of unmet care need consequences (UCNCs) related to ADL/IADLs, and to evaluate how caregiver status or treatment of hearing loss may modify this association. We hypothesized that older adults with hearing loss would have increased risk of experiencing UCNCs.

Design: Design: A study population of 3,582 adults was derived from a cross-sectional sample of the National Health and Aging Trends Study, a nationally representative ongoing prospective cohort study of Medicare beneficiaries aged 65 and older. Hearing status was assessed through self-reported difficulty hearing and audiometric hearing loss. Participants were asked if they had experienced UCNCs related to 11 ADL/IADLs within the last month. A binary variable was constructed to indicate the experience of at least one UCNC. Caregiver status was ascertained by participants' response to receiving help with any of 17 queried daily activities. Descriptive statistics were used to characterize the distribution of covariates and weighted multivariable logistic regression was used to examine the association between hearing loss and experience of UCNCs.

Results: Results: Among 3582 participants, 473 (11.3%) participants (mean age 79.1 years, 155 (38.2%) male, 272 (71.3%) White, 336 (63.9%) with any level of hearing loss) reported at least one UCNC. Participants with self-reported hearing loss (Odds Ratio [OR] 1.71, CI 1.19-2.46) and moderate or greater hearing loss (OR 1.68, CI 1.04-2.70), were each significantly more likely to experience an UCNC when compared to those with normal hearing, while those with mild hearing loss did not differ from the normal hearing group (OR 1.11, CI 0.79-1.55). Presence of at least one caregiver was associated with an increased likelihood of experiencing an UCNC (OR 2.43, CI 1.95-3.04). Among those with at least one caregiver, participants with moderate or greater hearing loss remained more likely to experience an UCNC (OR 1.67, CI 1.03-2.72). Untreated hearing loss was not significantly associated with experience of UCNC on multivariate logistic regression (OR 1.23, CI 0.78-1.97). Additionally, when stratified by those

with untreated hearing loss, no differences were observed regarding UCNC by degree of hearing loss (OR 1.23, CI 0.78-1.97).

Conclusions: Conclusion: In a nationally representative sample of 3,582 adults aged 65 and older, both self-reported hearing difficulty and audiometric hearing loss of moderate or greater severity were associated with increased likelihood of experiencing at least one UCNC, even among participants with at least one caregiver. These findings provide insight both to the importance of provision of long-term supports and services, but also ensuring sufficient support services for those at greater risk.

Category: Hearing Loss / Rehabilitation

Poster #: 057

Automatic Steering of Listening Support in Hearing Aids with Multi-Modal Sensor Integration

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Objectives: To provide listening support in challenging situations, hearing aids (HAs) combine spatial sound processing with advanced noise suppression strategies. Such features are typically automatically steered based on an acoustic analysis of the sound scene and the level of support chosen by the audiologist in the fitting software. However, in a sound scene with a given level of acoustic complexity, patients may still have different listening intents. In a busy restaurant, a guest conversing with a friend may face the same acoustic complexity as a waiter walking between tables, but their listening needs differ greatly. As head and body movements have been shown to be one of the key predictors to understand listening intentions, the goal of this study was to investigate the use of multi-modal sensor integration (MMSI) to steer HA automatic listening support. This novel approach uses the detection of head movements, body movements, and conversation activity, in addition to acoustic sound scene analysis and fitting software settings, as inputs to predict the patient's intent and steer listening support.

Design: We compared a HA using multi-speaker access technology (MSAT) with deep-neural-network (DNN) based noise suppression only (HA1) to a HA using MMSI coupled to MSAT and a newly trained DNN (HA2). Technical measurements, as well as three clinical studies, were performed to compare HA1 and HA2. In study 1, electroencephalography (EEG) responses to speech and environmental sounds were recorded in 30 experienced HA users fitted with HA2. In study 2, speech comprehension was tested for other 30 experienced HA users in a highly realistic setup. After freely orienting through a multi-talker complex scene with available visual cues, users were asked to follow a 30-second story spoken by one of the talkers and answer questions about the content. In study 3, sound quality ratings were also recorded via a questionnaire in six different simulated sound environments.

Results: For a given acoustic sound scene complexity, the output signal-to-noise ratio (SNR) measured with HA1 remained fixed, while HA2 provided an additional adaptation range of 5 dB. With all features set to default in both HAs, a 5-dB additional contrast between speech and noise was measured in HA2 compared to HA1, of which 3.5 dB resulted from MMSI and 1.5 dB were attributed to the improved DNN technology. The overall SNR improvement translated into a 35% higher Speech Intelligibility Index with HA2 than with HA1. In study 1, EEG responses were consistent with the desired effect of MMSI, whereby neural responses to environmental sounds were modulated by inferred listening intent. In study 2, speech comprehension was significantly higher by 15% with HA2 than with HA1. In study 3, subjective ratings were significantly higher with HA2 than with HA1 across all environments, showing better sound quality and higher listening comfort.

Conclusions: Overall, MMSI can help patients to better engage in diverse conversation activities by adapting listening support to their inferred intent.

Category: Hearing Loss / Rehabilitation

Poster #: 058

Combining Objective and Subjective Measures Strengthens Amplification Candidacy Recommendations

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Objectives: Hearing aids (HAs) are commonly recommended to patients with hearing loss. Traditionally, HA candidacy is determined by audiologists based on a combination of subjective hearing complaints and pure-tone audiometric thresholds. Now, over-the-counter (OTC) HAs might be pursued based on self-measured pure-tone thresholds and/or validated questionnaires of self-perceived hearing handicap. Recently, it has been suggested that a four-frequency pure-tone average (0.5, 1, 2, 4 kHz; "PTA4") holds utility as a straightforward hearing metric that can be used to guide individuals on HA candidacy, either in isolation or paired with a subjective questionnaire. In this study, we examine the relative strength of the PTA4 compared to subjective-only or combined objective-subjective metrics in predicting HA recommendations and outcomes.

Design: United States Service members (SMs) presenting for routine Hearing Conservation appointments were queried regarding history of a HA prescription and, if pursued, their subjective outcomes with the HAs. All SMs also completed the Hearing subscale of the Tinnitus and Hearing Survey (THS-H). A series of

objective-only (i.e., PTA), subjective-only (i.e., THS-H), and objective-subjective (i.e., PTA + THS-H) metrics were examined using receiver-operating characteristic (ROC) curve analyses for their strength in correctly classifying participants for two main questions: (1) Were HAs prescribed, and (2) Were the HAs worn? In addition, the PTA4 measure was compared to an alternative PTA, 1, 2, and 4 kHz ("PTA3"). The PTA3 and PTA4 measures were compared to specifically examine the predictive contribution of 500 Hz because it can be susceptible to interference from the noise floor when not measured in a controlled environment.

Results: Data collection is ongoing. The current data include responses from 5990 SMs aged 18-62; 236 SMs reported having been prescribed HAs. Those were further grouped into those who reported wearing the HAs "intermittently" or "full time" (n = 167), or those who reported either not pursuing HAs or no longer wearing their HAs (n = 69). ROC curves were fit for each metric, and the area under the curve (AUC) was calculated for each curve. Current findings show that AUC values are higher for the combined THS-H + PTA measures than for either measure alone, for both the Were HAs prescribed? and Were the HAs worn? analyses. A comparison of the questions indicates that the THS-H + PTA metric is a stronger predictor of the Prescribed question as compared to the Worn question. Comparisons of metrics involving PTA3 and PTA4 suggested no significant differences in AUC.

Conclusions: The findings of this study suggest that a combined objective and subjective measure of hearing is superior to either measure alone in predicting recommendation for HAs and subsequent HA use. Inclusion of 500 Hz in the PTA4 does not significantly improve its predictive capacity for these questions, suggesting that the 500 Hz threshold could be excluded if the noise floor is too high for measuring the threshold accurately.The views expressed in this abstract are those of the author(s) and do not necessarily reflect the official policy of the Department of Defense or the U.S. Government.

Category: Hearing Loss / Rehabilitation

Poster #: 059

Physical Activity and Function in Adults with Hearing Loss

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Objectives: To present objective and subjective physical activity and function data collected from middle-age and older adults with hearing loss and to compare physical outcomes from our sample to normative data from adults with normal hearing.

Design: This is an ongoing prospective, single-group, nonrandomized, pre-post clinical intervention study with hearing aid amplification. The inclusion criteria included 55-75 years of age and a mild-to-moderate sensorineural hearing loss. We measured pure-tone audiometry and objective and subjective physical activity and function at baseline. For physical activity measurement, we used an accelerometer (the ActiGraph wGT3X-BT) worn on the hip for 14 to 21 days, starting the day after the baseline visit. We used the Expanded Short Physical Performance Battery to assess physical function. We administered The

Baecke physical activity questionnaire and PROMIS V2.0 Mobility questionnaire for subjective measures of physical activity and function, respectively.

Results: We obtained data from 16 participants (10 males, 6 females; mean age =64.5 years, SD=5.5, range: 55-73). Around 80% of participants (13 of 16) wore the accelerometer for ≥ 10 hours per day for 8 or more days. 87.5% of participants (14 of 16) met the national guideline of ≥150 minutes per week of moderate-to-vigorous, aerobic physical activity when calculated using a threshold of 760 counts per minute. Our sample engaged in 50 fewer minutes of moderate-to-vigorous activity per day compared to a sample of similarly-aged adults with presumed normal hearing who wore the same accelerometer and whose activity was calculated using the same threshold. According to age- and gender-specific normative data, males fell in the 45th percentile (Mean: 5493, SD: 3492), and females fell in the 40th percentile (Mean: 3258, SD: 1906) for average number of steps per day. Participants exhibited poorer performance on the Expanded Short Physical Performance Battery (Total score Mean: 2.16, SD: 0.61) compared to other studies where this battery was administered in similarly-aged adults with normal hearing (Total score Mean: 2.82, SD: 0.4). Our participants' performance on this measure was commensurate with the performance of older adults age 70 to 79 years (Total score Mean: 2.17, SD: 0.55). Participants reported lower activity on the Baecke physical activity questionnaire (Mean, SD for each index: Work: 2.33, 0.71; Sport: 2.33, 0.75; Leisure: 2.6, 0.83) compared to normative data (Mean, SD for each index: Work: 2.75, 0.05; Sport: 2.6, 0.1; Leisure: 2.95, 0.05). Participants scored lower on the PROMIS V2.0 Mobility questionnaire (Mean T-Score: 48.76, SD: 8.79) than a normative sample of U.S. adults (Mean T-Score: 50, SD: 10).

Conclusions: Adults with mild-to-moderate hearing loss demonstrate poorer subjective and objective physical activity and function compared to previous studies with participants whose hearing was either not reported or was audiometrically normal. This work addresses important gaps in the research literature related to the measurement of physical outcomes and the characteristics of recruited participants. This work also adds to the growing body of evidence that adults with hearing loss are a vulnerable group characterized by a particularly inactive lifestyle and poor physical function who need intervention to improve physical outcomes.

Category: Hearing Loss / Rehabilitation

Poster #: 060

The Impact of Hearing Aid User Speech on Environment Classification

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Objectives: A variable for hearing aid (HA) environment classification and signal processing which has received little attention is the HA user's own voice. This lack of understanding between voice and HA signal processing leads to questions about HA signal processing in naturalistic settings where the user is speaking. It is unknown if the interfering effects of own voice on device performance are present across HA manufacturers, raising questions about the performance of adaptive features (e.g., noise reduction)

and feature validation methods. This study addressed this problem using electroacoustic testing of HA with an acoustic manikin, with the goals of advancing the methods used to study effects of own voice on HAs and answer how voice is interfering with environment classification across manufacturers. Based on pilot testing, it was anticipated the presence of own voice compared to simulated conversational partner's voice would lead to shifts in HA environment classifications from programs with one set of processing features (e.g., directional microphones) to programs with a different set of processing features.

Design: A manikin capable of approximating speech acoustics, wearing fully featured commercial HAs, produced vocal utterances in quiet and noise. The experimental testing occurred in a sound attenuating booth with 24-speaker array in the horizontal plane. Background noise and simulated speech were generated via custom software. The speech audio used for testing was the Arizona Travelogue, presented at 65 and 75 dB(C), with background noise emanating from 0, 90, 180, 270° and consisting of confluent cafeteria recordings and 10-talker babble presented at signal to noise ratios of -5, 0, +5, +10 dB SNR (re: speech level). Premium HAs from five manufacturers were tested and programmed to first fit settings. The outcome for this study is the status of HA environment classifications as indexed via device manufacturer fitting software data logs. The percentage of time an environment classification was active was assessed for each condition.

Results: Data analyses indicate the HAs tested in this experiment display shifts between multiple environment classifications and signal processing features when a simulated HA user is speaking versus conversational partner. This result was seen across manufacturers in noise conditions only, at all speech levels and SNRs tested. For some of the devices tested, the HA-user speaking conditions shifted from less aggressive to more aggressive signal processing (e.g. noise reduction), compared to when speech originated from the free-field. For other manufacturer's devices tested, the opposite effect was observed, with signal processing shifting from less to more aggressive for free-field speech relative to manikin speech.

Conclusions: The study findings indicate susceptibility for HA environment classification to process speech differently when arising from the device wearer compared to conversational partner. This potentially leads to situations when the device wearer is conversing in noise, the HA is switching between different processing features depending on who is talking. This has implications for the effectiveness of HAs as part of aural rehabilitation and raises questions about optimizing HA environment classification for the development and preservation of speech in individuals with hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 061

Hearing Healthcare Interventions in Rural America: A Scoping Review

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Objectives: Barriers to healthcare accessibility in rural communities are multifaceted and can negatively impact general health outcomes compared to those in urban or suburban localities. Individuals with hearing loss in rural communities may have geographic, financial, or sociocultural barriers to hearing health care that delay timely access to care. Little is known about the characteristics and quantitative outcomes of hearing health interventions implemented in rural areas. This scoping review's objective is to identify and review outcome of hearing healthcare interventions implemented among adults with hearing loss living in rural America.

Design: Data Sources: Search strategies derived from the study selection criteria (e.g., rural hearing health care interventions) using relevant MeSH and keywords for twelve databases were developed in collaboration with a Research Librarian (ES).Study Selection: Inclusion criteria was any hearing health intervention among an adult population with hearing loss in any rural health facility or community health setting, and reported quantitative outcomes. Rurality was defined as a county population of 49,000 or fewer. Inclusion criteria applied to intervention type were broad and included screening or diagnosis, communication management, or other interventions for hearing loss (hearing aids, voice amplifiers). Studies were excluded if they studied pediatric populations (17 and younger), culturally Deaf populations, or surgical interventions. Non-US-based studies or texts in languages other than English or Spanish were also excluded. Data Extraction and Synthesis: After removing duplicates, 1044 sources remained for title and abstract review and 41 relevant sources for full-text review. Eleven records were included in the scoping review. Two judges screened all sources; a consensus approach was used to address discrepancies across all steps of review (i.e., title/abstract, full text, data extraction, risk of bias assessment). Interrater reliability assessed using Cohen's kappa was fair to moderate across all steps.

Results: The 11 sources in the scoping review were 6 published texts, 4 ongoing clinical trials, and 1 completed trial with results not yet reported. Around one-third of studies utilized a communication management intervention. Others included amplification intervention, diagnostic assessments, patient accessibility/navigation, or amplification plus communication management. All experiments enrolled adults (18 years and older), and variations in interventions resulted in some study populations that did not have hearing loss. The most common study design was non-randomized interventional, followed by cross-sectional, and randomized interventional. Community-based participatory research was a common methodological framework for developing interventions within the communities that investigators intended to serve. Outcome measures varied based on study aims but generally revealed positive results across all 6 published texts.

Conclusions: The present review identified significant evidence gaps for rural hearing health interventions related to screenings, diagnostic assessment, and amplification. Rural hearing health interventions included in this review varied but generally produced favorable outcomes, regardless of type. Additional randomized trials are needed across all intervention types to increase the quality of available evidence. With several trials ongoing, we expect the body of evidence for rural hearing health interventions to grow in coming years. Standardization of methodological frameworks and outcome measures is recommended for improved quantitative evidence synthesis in the future.

Category: Hearing Loss / Rehabilitation

Poster #: 062

The Effects of Statin Use on Age-Related Hearing Loss

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Objectives: According to the World Health Organization (WHO), the world's population of individuals aged 60 years and over will double from an estimated 1 billion in 2020 to 2.1 billion in 2050. Approximately 1 in 3 people in the U.S. aged 65 to 74, and over half of individuals over 75 years, will experience age-related hearing loss (ARHL). Hearing loss can disrupt daily living making it difficult to carry on conversations with friends, family, employers and medical teams. Listening with hearing loss can be exhausting and cognitively demanding. ARHL typically presents as a gradual but progressive, bilateral, high-frequency hearing loss, first impacting high pitches that are necessary for understanding speech. Left unaddressed, hearing loss can have significant negative psychosocial consequences, including depression, anxiety, and has been linked to dementia. At present, there is no intervention to prevent age-related declines in hearing. Individuals that present with ARHL are typically treated with hearing aids. Despite significant technological advances in hearing aids, only 30% of individuals who could benefit from hearing aids choose to use them.There is an unmet need to identify candidate therapeutics that can prevent or slow the progression of age-related changes in hearing. Our lab and others have evidence in mice and humans that statin drugs, which are FDA approved to reduce cholesterol and risk of cardiovascular disease in adults, are associated with reduced hearing loss caused by ototoxic drugs or noise exposure. This study seeks to begin to examine the effect of statin use on age-related hearing loss in adults. We hypothesize that statin users would have delayed onset and/or reduced severity of hearing loss compared to non-statin users.

Design: We are conducting an observational clinical study to examine ear-specific hearing thresholds for 991 individuals (n=1,978 ears) across 6 U.S. clinical sites. Patient data reflective of middle ear pathology,

as defined by either tympanometry or audiometric air-bone gaps, were excluded from analyses. Audiologic records and demographic data from each site were standardized and aggregated into one Microsoft Excel File using the Excel vlookup function.

Results: The average age of participants in our cohort is 56 years, range 3 to 84, with 88% of patients aged 40 to 80 years. The majority (64%) are male. Statin use at the time of hearing evaluation was noted for 30% for patients aged 40-80 years. Though 5 different statins were noted among statin users, atorvastatin was the most commonly-used statin (52%).Data collection is ongoing. Planned analyses will compare hearing thresholds between atorvastatin users versus those not on statins for individuals aged 40+years . Variables such as age, race, ethnicity, sex, and medical history will be controlled for when possible.

Conclusions: Statins have been in clinical use for decades with few reports of side effects. Statin use during adulthood may offer a low-risk approach to reducing age-related changes in hearing This study's collaborative group is working to share relevant de-identified datasets in order to begin to address important clinical questions, including the effect of statin use on age-related hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 063

Speech Perception Outcome Differences Between Device Uses in Children with SSD

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Objectives: Aim 1: Determine whether clinically available behavioral measures show significant differences between patients with single-sided deafness (SSD) when using the following devices for listening in background noise: 1) contralateral routing of signal (CROS), 2) bone conduction sound processor (BCSP), 3) frequency modulation (FM) systems. Aim 2: Determine whether there are subjective performance differences between children who use the above devices for treatment of SSD. Hypothesis: There will be no differences in benefit between the three above non-surgical treatments for single-sided deafness.

Design: This was a prospective crossover study. Participants included 9 children, aged 8-14 years, with stable single-sided deafness (SSD). SSD was defined as unilateral severe-to-profound sensorineural hearing loss with pure tone average (PTA) of 70dBHL or poorer at 500, 1000, 2000 and 4000 Hz in the affected ear, and PTA of 20dBHL or better in the unaffected ear. Hearing loss stability was defined as no greater than 10dB change in threshold at any frequency from 250-8000 Hz within the last 3 years.Other than hearing loss, all participants were healthy and did not have a history of co-morbidities. Exclusion criteria included meningitis, temporal bone fracture, 8th nerve tumor, known progressive hearing loss within the past 3 years, otitis media with effusion within the past 2 years, atypical cognitive development,

need for behavior modification therapies or medications, individualized education plan (IEP) in use, and use of a personal FM, BCSP or CROS within the last 6 months. Participants were seen over 5 visits. A hearing evaluation was completed at the first visit. Participants were fit with either a CROS, BCSP, or FM system at visits 2-4. Participants trialed each device for 3-5 weeks. Speech perception testing (BKB-SIN) and questionnaires (uniHELO, Pediatric and Parent SSQ) were completed at each visit.

Results: Overall, use of the FM system resulted in significantly better BKB-SIN average SNR-50 scores compared to CROS, BCSP, or no device use across all test conditions. Use of CROS, BCSP or FM resulted in significantly improved BKB-SIN average SNR-50 scores compared to no device when the signal was directed towards the poorer ear. Use of a CROS, BCSP or FM did not significantly impact speech-in-noise performance when the signal was directed to the better hearing ear, compared to no device use.Questionnaire test-retest reliability between visits 1 and 2 was reported. Results showed that uniHELO questionnaire had the highest correlation values, compared to Pediatric and ParentSSQ. Average uniHELO and average ParentSSQ scores with FM use were significantly higher compared to no device use evaluated by mixed effects models.

Conclusions: In this study, children with SSD showed the most benefit from use of personal FM in background noise. In general, children performed better on speech perception tests in noise with a device compared to unaided. Use of personal FM, CROS, or BCSP devices should be recommended to children with single-sided deafness. Compared to no device, FM was the only device that showed significant subjective benefit. The uniHELO instrument is a reliable clinical tool to access pediatric subjective benefit for children with SSD.

Category: Hearing Loss / Rehabilitation

Poster #: 064

The Impact of Hearing Aids on Emotional Response to Music

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Objectives: Hearing aids were traditionally designed for speech, rather than music listening. Moreover, the impact of hearing loss on the emotional response to music is not well-studied. Our objective was to examine the impact of hearing loss and hearing aids on the emotional response to music. We hypothesized that hearing aids would positively impact the emotional response to music.

Design: A cross-sectional online survey was administered via a computer with speakers to adult (≥18 years) bilateral hearing aid users (n=110) recruited from a community and tertiary medical center setting. Participants listened to ten validated 15-second musical stimuli across wide range of valence (happiness vs. sadness) and arousal (excitement vs. calm), with and without hearing aids. Emotional response was rated using the Self-Assessment Manikin (SAM) scale, a validated nine-point pictographic scale used to assess emotion. The two outcome measures for emotional response included emotional range and error (deviation from published reference rating in normal hearing individuals). Error values of zero indicate responses identical to reference ratings. Paired t-tests were used to perform within group comparisons of emotional response to music with and without hearing aids. Multivariable linear regression was performed to assess the association between hearing loss severity (pure tone average of the better hearing ear) and emotional response adjusting 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 music discrimination ability).

Results: Mean (standard deviation [SD]) age was 67.3 (17.7) years; 70.3% were female. Mean (SD) pure tone average of the better ear was 53.4 (17.4) dBHL. Twenty-two (20%) subjects had mild hearing loss (26-40 dBHL), 70 (64%) moderate to moderately severe hearing loss (41-70 dBHL), and 18 (16%) severe hearing loss or worse (≥71 dBHL). Mean (SD) length of hearing aid use was 13.4 (12.2) years. Mean (SD) word recognition score of the better ear was 80.5 (21.0) %. Mean (SD) musical experience was 5.8 (7.8) years; 35.6% had some level of musical experience. Hearing aid use resulted in decreased error in valence identification (aided 1.63 vs. 1.82 unaided, $p<0.01$) across all participants. Hearing aid use also resulted in increased range of valence (5.78 aided vs 5.41 unaided, $p=0.01$) and arousal (aided 5.56 vs. unaided 5.04, $p<0.01$), as well as increased appreciation of maximum valence (aided 7.88 vs. unaided 7.47, $p<0.01$) and arousal (aided 7.79 vs. unaided 7.11, $p<0.01$) across all participants.Multivariable linear regression demonstrated increased severity of hearing loss (pure tone audiometry of the better hearing ear) was independently associated with increased error in unaided valence detection (estimate 0.11±0.09, $p=0.02$); for every 10-dB worsening in hearing loss, there was an additional 0.11-point error in unaided valence detection. Hearing loss severity was not associated with error in aided valence detection or with error in arousal detection in aided or unaided conditions.

Conclusions: Hearing aids may improve the emotional response to music in individuals with hearing loss. Increased severity of hearing loss may be associated with a decreased emotional response to music.

Category: Hearing Loss / Rehabilitation

Poster #: 065

Using Ecological Momentary Assessment to Determine if An Intervention to Change Views of Aging Affected Daily Listening Activities

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Objectives: Only about 1 in 5 people who have audiometrically defined hearing loss seek help for hearing problems. This study examined the potential of an intervention, the Aging + Hearing (A+H) program, to reduce negative views of aging and self-directed ageism as possible barriers to help-seeking. The A+H program emphasizes goal setting to increase engagement in listening, with participants setting individualized goals for solo and inter-personal interactional listening activities. Here we report on the effect of the A+H program on the quality and quantity of daily listening activities measured using Ecological Momentary Assessment (EMA).

Design: Community-dwelling older adults without hearing aids completed online baseline measures, including a battery of questionnaires, hearing screening (SHOEBOX), and cognitive screening (Cogniciti). The questionnaires included EMA surveys sent out twice a day (at noon and 6pm, with questions about all listening activities over the preceding 6 hours and about experiences in the most recent activity) for 7 days (14 total surveys) at each of three assessment times. Each EMA survey consisted of 13 items and took about 5-minutes to complete. EMA data were analyzed for 136 participants (mean age = 71 years, women = 87, men =39) who completed at least two EMA surveys at each of the three assessment times, with 67 in the training group and 69 in the waitlist control group. The groups were matched on five dichotomous characteristics: age, sex, hearing, cognition, and views of aging. The training group underwent the A+H online group program, consisting of four 2-hour sessions. Assessments were conducted at baseline, immediately post and 10 weeks post training, with the timing of assessment for participants in the control groups yoked with the timing for the training groups.

Results: Preliminary multilevel modelling found that A+H training resulted in increased attention (concentration/effort) allocated to daily listening activities by those in the training group, but no change in the control group. Sub-group analyses revealed that this training effect was stronger for men than women, as well as participants who were younger (52-70 years old), had hearing loss, normal cognition, and more negative views of aging at baseline. Notably, the A+H training effect on attention during daily listening activities was driven by solo rather than inter-personal listening activities. Surprisingly, training also affected the number of listening activities that participants engaging in, with a decrease following training (mean = 3.5 activities at baseline vs. 2.8 activities at the immediate and delayed assessment times). The decrease in number of activities was observed for older (> 70 years) participants and those with normal hearing, cognitive loss, and more positive views of aging at baseline (i.e., opposite characteristics to those who increased attention).

Conclusions: The A+H training program increased the attention allocated (quality of listening activities) when older adults with hearing loss, normal cognition, and more negative views on aging at baseline engaged in daily listening activities. Those with the opposite characteristics reduced the number of their listening activities (selection of listening activities).

Category: Hearing Loss / Rehabilitation

Poster #: 066

Adding Survey to PTA4 Produces Better Prediction of Speech-in-Noise Performance

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Objectives: In an effort to expand hearing aid access, there has been rising interest in using the pure-tone average of 500, 1000, 2000, and 4000 Hz (PTA4) as a metric for guiding hearing aid candidacy. Toward this end, in 2023, the Consumer Technology Association (CTA) published guidelines on measuring PTA4 outside of the audiology clinic. The guidelines include qualitative descriptions of speech-in-noise performance for individuals with a range of PTA4s from the World Health Organization (WHO), suggesting that PTA4 is capable of directly predicting speech-in-noise performance. One goal of this study was to determine the efficacy of using PTA4 to predict speech-in-noise performance. Along with pure-tone audiometric testing, it is common practice in clinical audiology to administer questionnaires or engage patients in discussions to assess specific needs and challenges. In order to capture the counseling aspect of clinical audiology, and to determine whether such a questionnaire would improve predictions of speech-in-noise performance, a concise, four-question survey (the hearing subscale of the Tinnitus and Hearing Survey [THS-H]) was administered to patients. This survey evaluates self-perceived difficulty understanding speech in everyday environments. A second goal of this study was to determine if adding the THS-H to the PTA4 improved model predictions of speech intelligibility.

Design: A cohort of 2,633 United States Service Members were recruited for this study. After consenting, participants completed a battery of tests, including pure-tone audiometry, several surveys (including the THS-H), and a speech-in-noise test. The speech-in-noise test was the Modified Rhyme Test (MRT), a closed-set speech intelligibility task where listeners must choose a target word (e.g., BAT) out of several alternatives that only differ in the consonant sound that comes first (e.g., CAT, HAT) or last (e.g., BALL, BAR). Targets were always presented in noise. The signal-to-noise ratio (SNR) varied between -12 and 4 dB. The level of the target varied between 56 and 84 dB SPL. Mixed-effects models were fitted to predict trial-level performance on the MRT with PTA4, self-reported hearing difficulty as measured by the THS-H, and a combination of the two as predictors. SNR, presentation level, age and gender were added as covariates.

Results: All models were significant fits to the data. PTA4, THS-H scores, and a combination of the two all predicted performance on the speech-in-noise task (MRT). To determine which best predicted MRT performance, models were compared using Akaike Information Criterion. The model with PTA4 and THS-H was found to be a significantly better fit than the model with PTA4 alone.

Conclusions: Based on the results of this study, PTA4 predicts speech-in-noise performance, but its predictive power is strongest when combined with a subjective hearing difficulty questionnaire (THS-H). This outcome supports clinical practice guidelines that promote the use of objective and subjective hearing measures to guide management options.[The views expressed in this abstract are those of the

author(s) and do not necessarily reflect the official policy of the Department of Defense or the U.S. Government.]

Category: Hearing Loss / Rehabilitation

Poster #: 067

Management of Severe Hearing Loss in the VA: A Mixed Methods Study

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Objectives: Hearing loss is a common service-connected disability among Veterans and extensive hearing care resources are prioritized within the Veterans Health Administration. The VA is the largest dispenser of hearing aids with an annual budget of $300 million. The underlying hypothesis is that Veterans with severe hearing loss require distinct treatment to address communication not adequately addressed by amplification. We describe the management of Veterans with severe hearing loss contextualized with perspectives of Veterans and their audiology and medical providers within the VA health care system.

Design: A sequential explanatory mixed methods design was used to inform the quantitative data with qualitative data. The quantitative data analyzed included the VA Audiometric Repository and the relationship of hearing loss severity with speech recognition abilities (individual ear word recognition score) and treatment modality ordered from the Remote Order Entry System (ROES) (no treatment, amplification and cochlear implantation) from 2005-2022. This database was linked to sociodemographic characteristics, comorbidities, geography, proximity to VA facilities and data from VA health records so that longitudinal data and changes in management could be observed.For the qualitative data, providers and Veterans were recruited for semi-structured interviews using a purposive sampling strategy until data saturation was reached. We emphasized maximal variation to enroll 20 audiologists from around the nation, 10 otolaryngologists from different geographic regions, and 4 primary care providers, and (total sample = 34). We also interviewed 39 Veterans with severe hearing loss at different VA facilities around the country including both urban and rural settings with individuals of diverse backgrounds.

Results: We identified a cohort of 137,500 unique Veterans with 232,789 audiograms demonstrating bilateral severe or worse hearing loss during this time period. Among those with bilateral severe or worse hearing loss, 41,901 (30.5%) also had poor speech recognition scores (<50% words correct), with greater hearing loss severity correlating with worse speech perception. Approximately 80% of Veterans with severe hearing loss had been dispensed hearing aids while less than 2% of Veterans in this cohort received cochlear implants within the VA healthcare system.In the qualitative descriptive study examining provider perspectives of facilitators and barriers to evidence-based care of Veterans with severe hearing loss, the consensus among the providers (n=33) was that hearing loss was undertreated in the Veteran population; many more Veterans would benefit from hearing evaluation and treatment.

Across provider groups which included audiologists, otolaryngologists and primary care providers, the qualitative data revealed multi-level including system-level (e.g., workflow issues and organizational practices), provider-level (e.g., knowledge and experience) and patient-level factors (e.g., Veterans' attitudes, acceptability and health status) that influence the delivery of hearing care for Veterans with severe hearing loss.

Conclusions: Severe hearing loss is prevalent among Veterans and many have reduced communication abilities that may not be remedied by amplification alone. While the VA prioritizes hearing health care and offers comprehensive hearing services, various patient-level, provider-level and system-level barriers were identified which require targeted interventions to ensure evidence-based management.

Category: Hearing Loss / Rehabilitation

Poster #: 068

Feasibility of the Quick-VC Test for Evaluating Hearing Aid Benefit

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Objectives: Audiograms do not always explain a listener's self-reported hearing difficulties, particularly hearing in the presence of background noise. A quick speech-in-noise test, called Quick-VC, has been developed that is sensitive to hearing loss beyond audiometric thresholds and has shown potential for identifying and quantifying unexplained hearing difficulties and hearing aid benefit. Reliability and efficiency of the Quick-VC test was compared to a commonly used clinical speech-in-noise test, QuickSIN, to evaluate Quick-VC's clinical feasibility.

Design: The Quick-VC test consists of ten vowel-consonant-vowel (VCV) tokens that are mixed with speech-shaped noise at signal-to-noise ratios that were determined to be sensitive to hearing loss in a previous study. Adults with normal hearing and a range of hearing losses completed the Quick-VC test twice with 100 trials each and two sets of two lists of the QuickSIN test. Participants with hearing loss repeated the tests with a hearing aid fit by an audiologist in the lab. The correlation between the scores of the first and second tests were used to assess test reliability. Mean absolute differences between tests were evaluated as a function of test time to evaluate test efficiency. Hearing aid benefit was quantified by comparing scores between unaided and aided conditions.

Results: QuickSIN repeatability was improved by averaging scores from two different lists. Repeatability of Quick-VC was similar to QuickSIN. Quick-VC repeatability at 50 trials was equivalent to the QuickSIN average of two lists. Hearing-aid benefit was observed on both tests for participants with hearing loss and was similar between tests. However, the hearing-aid never restored normal performance on either test.

Conclusions: Quick-SIN and Quick-VC have similar repeatability when test times are equated. A two-minute test utilizing either Quick-SIN or Quick-VC could provide reliable indication of hearing-aid benefit.

Compared to Quick-SIN, Quick-VC has the advantages of less learning effects, lower cognitive demand, automated scoring, and potential for PTA prediction.

Category: Hearing Loss / Rehabilitation

Poster #: 069

User's Perspectives of a First Hearing Aid Fitting

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Objectives: This study is the first step in a project whose goal is to develop an intervention program for first-time hearing aid (HA) users and their relatives. The general objective was to identify the foundations on which to build the program. Specific objectives were: (1) To identify the facilitators and barriers to a successful HA fitting from the perspective of adults and seniors with acquired HL, their relatives, and hearing care professionals (HCPs); (2) To identify the elements to include in the new intervention program; (3) To assess the satisfaction of people with HL and their relatives regarding HAs and fitting services. (4) To assess social participation among first-time HA users and their relatives after 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 10 new HA users, 7 of their relatives, and 10 HCPs (5 audiologists and 5 HA specialists). HA users also completed two questionnaires to assess their satisfaction with HAs and fitting services and their social participation after fitting. Participants were recruited from HA dispensing and audiology clinics around the Province of Qu√©bec, Canada, to ensure a variety of backgrounds and perspectives. A deductive/inductive qualitative content analysis was done on data obtained from the interviews. A descriptive group analysis was completed on quantitative data.

Results: The data collection is completed, and analyses are presently being performed. The following results are preliminary. Final results will be presented at the Conference. Factors that facilitate or hinder a first HA fitting have been identified during interviews with HCPs, people with HL, and their relatives. The most frequently reported are related to: (1) Professional services (e.g., proximity of service, relation of trust with the HCP). (2) Hearing aids (e.g., their cost and performance). (3) Close relatives (e.g., their perception and expectations regarding HAs). (4) Personal factors (e.g., expectations and motivation). Elements that should be included in the intervention program were identified and classified in two categories: (1) Information to provide (e.g., benefits and limitations of HAs; adaptation to HAs; brain plasticity, sensory deprivation, and cognition; communication strategies; other hearing assistance technologies; professional services to support HA fitting and adaptation). (2) Support to provide (e.g., pre-fitting support; post-fitting follow-up; support to relatives; rehabilitation services and group activities; support to raise public awareness about HAs and HL). Finally, participants with HL reported high levels of satisfaction regarding HAs and fitting services (>85%). They also reported having a high level of social participation with the use of HAs (>90%).

Conclusions: Results show that a variety of factors can influence the success of a first HA fitting. Those factors are not only related to HAs, but also to the services offered by professionals and by psychosocial elements. Participants also suggested important components to include in the intervention surrounding a first HA fitting. Those results will be used in the following part of the project to develop an intervention program for first-time HA users and their relatives. Ultimately, the new intervention program will help those people to improve their use of HAs, which will in turn improve communication and social participation.

Category: Hearing Loss / Rehabilitation

Poster #: 070

Effect of Hearing Intervention on Mental Health: Findings from the ACHIEVE Study

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Objectives: Prior observational studies show associations between hearing loss and worse social and mental health among older adults. Whether hearing loss treatment is an effective intervention is unknown. The Aging and Cognitive Health Evaluation in Elders (ACHIEVE, Clinicaltrials.gov Identifier: NCT03243422) randomized controlled trial tests the effect of a best-practices hearing intervention vs. health education control on change in pre-specified exploratory outcomes of social isolation, loneliness, depressive symptomology, and health-related quality of life among older adults with hearing loss over 3 years.

Design: The ACHIEVE study enrolled 977 community-dwelling adults aged 70-84 years at baseline (2018-2019) with untreated hearing loss (better ear pure tone average [0.5-4 kHz] ≥30 and<70 dB HL) and without substantial cognitive impairment from four sites across the U.S. (Jackson, MS, Forsyth County, NC, Minneapolis, MN, Washington County, MD). Participants were randomized to hearing intervention (provision of hearing aids and related technologies, counseling, and education) or health education control (individual sessions with a health educator covering topics relevant to chronic disease and disability prevention) and followed semi-annually for 3 years. Pre-specified exploratory outcomes included social network characteristics (social network size, social network diversity, network embeddedness [Cohen Social Network Index]), loneliness (UCLA Loneliness Scale), depressive symptomology (11-item Center for Epidemiologic Studies Depression scale), and eight domains of health-related quality of life (RAND-36 Health Survey). Linear mixed effects models tested whether 3-year change in social and mental health outcomes differed by intervention assignment. Models were adjusted for demographic characteristics, baseline cognition, baseline hearing loss severity, and study design characteristics (study site, recruitment source, spousal pair). Missing outcome and covariate data was imputed using multiple imputation by chained equations.

Results: Mean (SD) age at baseline was 77 (4) years; 88% were White, 54% were female, and 53% had a Bachelor's degree or higher. Mean (SD) pure tone average was 39(7) dB HL. Compared to health education control, the hearing intervention had a protective effect over 3 years on loneliness (difference: -0.39 [95% CI: -0.68, -0.10]), social network size (difference: 0.37 [95% CI: 0.01, 0.74]), diversity (difference: 0.08 [95% CI: 0.02, 0.14]), and embeddedness (difference: 0.10 [95% CI: 0.04, 0.16]) over 3

years. In analysis of domains of health-related quality of life, hearing intervention had a protective effect for social functioning (difference: 2.63 [95% CI: 0.07, 5.20]) and suggestion of an effect for higher energy/less fatigue (difference: 1.71 [95% CI: -0.13, 3.55]) over 3 years. No statistically significant difference in 3-year change in depressive symptoms was observed by intervention assignment.

Conclusions: Hearing intervention has sustained benefits for social health and well-being. Existing interventions for improving social health and well-being are limited in effect size, follow-up time, and scalability. Hearing intervention may be a valuable intervention to complement existing interventions targeting social health and well-being.

Category: Hearing Loss / Rehabilitation

Poster #: 071

Vision and Hearing Difficulty Modify Effects of Cognitive Training in Older Adults

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Objectives: Cognitive training interventions are delivered visually and/or aurally. Whether sensory loss modifies their effects in older adults is unknown. We assessed differences in the effect of the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study, a randomized cognitive training intervention trial, by self-reported vision and hearing difficulty.

Design: Participants (65 years and older, cognitively/functionally healthy) were randomized to cognitive training in memory, reasoning, or speed of processing or a no-contact control. Composite scores were created using multiple cognitive assessments in memory, reasoning, and speed of processing. Self-reported near vision difficulty was defined as reading ordinary print in the newspaper (no difficulty/a little or some difficulty), and hearing loss was self-reported (yes/no). Differences in the 10-year effect of cognitive training on change in trained cognitive ability were assessed using linear mixed effect models adjusted for demographic and study design characteristics.

Results: Among 2,788 participants, 22% reported vision difficulty and 43% reported hearing loss. Participants with sensory loss benefited from all cognitive training interventions (Figure 1); however, the magnitude of benefit of reasoning training was smaller among participants with vs. without vision difficulty (10-year difference in reasoning ability [intervention vs. control]: vision difficulty: -0.25, 95% CI: [-0.88, 0.39], no vison difficulty: 0.58, 95% CI: [0.28, 0.89]). Magnitude of benefit of memory training was greater for participants with vs. without hearing loss (10-year difference in memory ability [intervention vs. control]: hearing difficulty: 0.17, 95% CI: [-0.37, 0.72], no hearing difficulty: -0.20, 95% CI: [-0.65,0.24]). Beneficial effect of speed of processing training was similar by sensory status.

Conclusions: Participants with vision difficulty did not benefit as much from reasoning training, likely because training required more visually complex exercises (e.g., deciphering patterns across similar symbols). Memory training was more efficacious for participants with hearing loss, perhaps because training provided compensation strategies for overcoming cognitive load (increased effort for processing

degraded auditory signals). Individuals with sensory loss have increased risk for cognitive decline and should not be excluded from cognitive training interventions as magnitude of benefit may be greater for these individuals.

Category: Hearing Loss / Rehabilitation

Poster #: 072 **Mentored Student Research Poster Award**

Functional Auditory-Nerve Recovery Despite Persistent Synapse Loss After Excitotoxic Injury

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Objectives: Sound information is communicated from the cochlea to auditory nerve fibers (ANF) via the neurotransmitter glutamate. Besides its fast excitatory properties, glutamate is known to have neurotoxic properties when excessively released from the inner hair cell or incompletely recycled. In work that revealed dramatic noise-induced loss of cochlear synapses and neurons in ears with recovered thresholds and hair cells, we hypothesized that excitotoxic insult was a primary instigator of cochlear deafferentation and that fibers with low spontaneous rates (SR) of firing were particularly vulnerable. As sound-driven response properties vary with SR, clarifying these relationships is key to understanding perceptual effects of deafferentation after noise.Work summarized here aimed to: 1) clarify the role of glutamate excitotoxicity in noise-induced cochlear deafferentation using pharmacologic, physiologic and histologic tools and 2) characterize, by ANF subtype, initial vulnerabilities and patterns of recovery after noise vs glutamate agonist excitotoxicity.

Design: Experiments were conducted in Mongolian gerbil, an animal with a range of hearing sensitivity largely overlapping human, with known cochlear distributions of ANFs by SR subtype. The overall design involved exposing young adult gerbils (n=113) to a single noise insult (103dB, 2hr) or a single application of glutamate agonist (kainate; 25mM in artificial perilymph, 1hr). Physiologic consequences of these exposures were assessed by comparison with controls (n=92), by recording distortion product otoacoustic emissions (DPOAE), compound action potentials (CAP), peri-stimulus time responses (PSTR), single-ANF responses including peristimulus-time histograms (PSTH), and unstimulated round-window neural noise, correlated with analyses of immunostained cochlear tissues to assess hair cells and afferent synapses.

Results: Noise exposure yielded threshold shifts in both DPOAEs and neural responses that recovered to control values by 2wk, without hair cell loss. High-SR dominated sound-evoked responses and

spontaneous neural noise recovered, exceeding control values at some post-exposure times. PSTR plateaus, reflecting contributions of neurons from all subgroups, recovered but never exceeded controls. In the same ears, synapse loss was persistent, even 8 months post exposure. In kainate-treated animals, DPOAEs were not different from controls. Ultrastructural examination showed swelling of afferent terminals and disruption of ribbon synapses 3hr post drug. Although completely abolished at this time point, CAP thresholds and amplitudes progressively recovered from day 1 to 4 months. In contrast, synapse counts remained significantly reduced at 4 post-drug months. To probe this apparent discrepancy, we recorded spontaneous and sound-driven activity from single ANFs. Importantly, fibers from kainate-treated ears displayed higher SRs than controls, and better synchronization indices as revealed by the increased onset peak of the PSTH.

Conclusions: Gerbil auditory nerve activity recovered from both noise- and kainate-induced excitotoxic insults despite persistent synapse loss. As revealed by single-fiber data, mechanisms of this neural recovery rely on phenotypic changes in remaining/regenerated fibers. This is the first demonstration of a compensatory mechanism occurring at the ribbon synapses in response to excitotoxic injury. Enhanced synaptic gain may be a potential mechanism to compensate for ANF loss after excitotoxicity. Supported by: Department of Defense grant W81XWH2120027, Gueules Cass√©es Foundation Grants NN34-2019 and 35-2019, Sheldon and Dorothea Buckler Fund.

Category: Hearing Loss / Rehabilitation

Poster #: 073

Hearing Loss, Hearing Aid Use, and Fatigue

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Objectives: Managing fatigue is critical for maintaining daily functioning and preventing physical, mental, and occupational impairments among older adults. Hearing loss might increase fatigue by increasing the listening effort required to compensate for communication difficulties. Prior evidence from the general population is limited. Additionally, whether hearing aids mitigate fatigue remains unclear. We investigated cross-sectional associations of hearing loss and hearing aid use with fatigue in a nationally representative sample of U.S. Medicare beneficiaries.

Design: We included 2,383 participants aged ≥71 years from the National Health and Aging Trends Study round 11 (year 2021). Fatigue was based on two self-reported questions regarding: (1) whether the participant had low energy or was easily exhausted; (2) whether low energy or exhaustion limited activities. Participants were categorized as having no fatigue, fatigue without limitations, and fatigue with limitations. We calculated the better-ear four-frequency (0.5, 1, 2, 4 kilohertz) pure-tone average in decibels hearing level (dB HL), and participants were categorized as normal (< 25 dB HL), mild (26-40 dB HL), and moderate or greater (>40 dB HL) hearing loss. The hearing loss-fatigue association was

examined using multinomial logistic regression to estimate relative risk ratios (RRR) of being in a higher vs. no fatigue (reference) category across hearing loss categories. Given that older adults are commonly living with comorbid conditions and fatigue is a common symptom of comorbidities, we further stratified the analysis to examine whether the hearing loss-fatigue association differs by number of health conditions (≥3 vs.<3). The association between self-reported hearing aid use (Yes/No) and fatigue among participants with hearing loss was also estimated using multinomial logistic regression. Models adjusted for age, sex, race/ethnicity, education, smoking, body mass index, and number of health conditions.

Results: When compared to normal-hearing participants, participants with moderate or greater hearing loss were 1.42 times (95% confidence interval [CI]: 1.00, 2.03) more likely to have fatigue with limitations vs. no fatigue. The association between hearing loss and fatigue was statistically significantly stronger (P-interaction = 0.01) among participants with<3 health conditions (RRR=1.67, 95% CI: 1.14, 2.45) vs. those with≥3 conditions (RRR=0.69, 95% CI: 0.32, 1.52). Among 1,717 participants with hearing loss, hearing aid users were less likely to have fatigue without limitations (RRR=0.64, 95% CI: 0.42, 0.98).

Conclusions: Older adults with hearing loss may experience increased fatigue, but hearing aids might be a promising strategy to mitigate fatigue among older adults with hearing loss. Taking a holistic patient care approach and working in interprofessional teams to consider other health conditions together with hearing loss is important for older adults commonly living with comorbidities.

Category: Hearing Loss / Rehabilitation

Poster #: 074

Musicality and Hearing Sensitivity in Older Adults: Population-Scale Associations

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Objectives: Converging evidence shows that musical abilities and hearing traits (e.g. hearing speech in noise) are positively correlated. Additionally, substantial variation in musicality, which includes aptitude and engagement, and developmental communication-related disorders are driven by genetic factors. To investigate possible shared genetic architectures, we must first establish robust phenotypic connections. Using data from the Canadian Longitudinal Study of Aging (CLSA), we aimed to test associations between musicality and hearing sensitivity in a large-scale epidemiological cohort of older adults. We hypothesize that greater musical engagement will be associated with improved hearing in older adults, consistent with models of musicality as a protective factor.

Design: We examined cross-sectional relationships between hearing sensitivity and four music engagement items in which CLSA participants (N=10,721 (50.2% Female); Mean Age=72.9 yrs; Standard Deviation of Age=5.63 yrs) reported (1) their frequency of playing an instrument or singing in a choir.

Our approach follows previous work with CLSA data whereby music engagement frequency was dichotomously coded as "often", for once per year or more frequently, and "not often." Other variables included (2) whether participants sat and played an instrument or (3) sat and listened to music in the past week; and (4) whether they engaged with a music-related program in the past week.¬†Multivariate linear regressions were performed¬† to assess the effects of music engagement on hearing sensitivity, measured by pure tone audiometry threshold of the better hearing ear (Better Ear PTA). Age, sex, educational attainment, and hearing aid use were included as covariates. All participants were aged 65 years or above and from CLSA's "baseline" data version 3.0 with complete reports for musicality variables, PTA measures, and covariates.

Results: Mean Better Ear PTA in the sample was 23.96 dB hearing threshold level (SD=11.53 dB) and within the clinical normal hearing range, i.e.<25 dB. Multivariate linear regression models showed that higher frequency of playing or singing music was associated with better hearing sensitivity, controlling for covariates (β=-1.1; SE=0.23; p<.0001). That is, engaging in music "often" (N=2,088) was associated with a 1.1 dB decrease in Better Ear PTA threshold, compared to engaging "not often" (N=8,633). The overall model explained 33.5% of the variability in hearing sensitivity (model R2=0.33; model p<.0001). Other musicality measures were not significantly associated with hearing sensitivity.

Conclusions: Our results support our hypothesis that higher degrees of musical engagement predict better hearing sensitivity in older adults. These findings are consistent with studies demonstrating that lower degrees of musicality are risk-factors for developmental communication-related disorders. Our results highlight the importance of studying age-related hearing loss within this framework. This could lead to novel, musicality-based, clinically-relevant tools for screening and treating age-related speech and hearing problems. Alternative explanations may include that older adults with better hearing engage with music more frequently. However, given emerging evidence that individual differences in musicality and hearing loss are substantially driven by genetic factors, future research should fully explore the potential of musicality as a genetically-driven protective factor for hearing health.

Category: Hearing Loss / Rehabilitation

Poster #: 075

DHH Students' Experiences with Higher Education's Real-Time Captioning Services

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Objectives: Real-time captions appear to be an effective tool in assisting deaf and hard of hearing college students access information and communication in certain classroom settings. However, there is limited knowledge of these students' direct experiences with real-time captioning services. This research provides an in-depth exploration of deaf and hard of hearing college students' experiences using real-time captioning services by answering the following question: What types of stories do deaf and hard of hearing students share about their experiences with real-time captioning services in higher education?

Design: In this prospective qualitative study, we used a narrative approach. Specifically, we conducted narrative interviews with 15 deaf and hard of hearing college students who used CART, TypeWell, or C-Print real-time captions in at least one university class. We then used thematic narrative analysis to identify the types of stories shared by these college students about their experiences with real-time captioning services.

Results: Thematic narrative analysis revealed four story types: (1) stories of overcoming barriers, (2) stories of resignation, (3) pragmatic stories, and (4) stories of personal connection.

Conclusions: In the present study, different types of stories emerged from deaf and hard of hearing students' experiences that suggest these students find increased communication access through real-time captioning services. However, these stories also reveal that students often face significant barriers to successful real-time captioning use, and effective communication is not always occurring as intended. These findings specifically contribute to the field by providing educators and professionals with new insight into deaf and hard of hearing students' sensemaking regarding real-time captioning services in higher education, and can inform the provision of more equitable accessibility services.

Category: Hearing Loss / Rehabilitation

Poster #: 076

Person, Place, and Time: Sampling Considerations for Auditory Ecology Research

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Objectives: Creating hearing loss interventions with real-world effectiveness requires an understanding of the listening activities and soundscapes-the auditory ecology-of listeners in their daily lives. Most research on auditory ecology has used demographically homogeneous samples and short, singular sampling periods. What is a representative and valid sample with respect to listener demographics, location of sampling, and sampling time? What factors need to be considered when designing studies of auditory ecology and generalizing the results? These questions are critical, as collecting real-world data is time and resource consuming. In this presentation, we first propose a model of quantifying auditory ecology in terms of listening demand and soundscape diversity. Then, we present several studies aiming to address important methods questions by investigating the effects of age, location, race, ethnicity, and culture, and sampling timeframe on auditory ecology.

Design: The presented studies used ecological momentary assessment, audio recordings, hearing aid data, and dosimeter data to measure auditory ecology. Auditory ecology was quantified by listening demand, with higher sound levels and more demanding listening activities indicating more demanding auditory ecology, and soundscape diversity, with less predictable sound levels and listening activities indicating more diverse auditory ecology. Study 1 (age and location, N=46) compared auditory ecology among older listeners with hearing loss and younger listeners with normal hearing from an urban and rural location. Studies 2 (race, ethnicity, N=33) and 3 (culture, N=74) compared auditory ecology

between younger listeners who identified as white or nonwhite and Latinx or European-American. Study 4 (time, N=36) compared auditory ecology among listeners at 3 time points, characterizing the effects of week, season, day, and time of day on auditory ecology.

Results: Older listeners had less demanding and less diverse auditory ecology than younger listeners. Rural listeners had less demanding and less diverse auditory lifestyles than urban listeners. White and nonwhite listeners did not generally differ in auditory ecology demand or diversity, though listening activities and social network sizes did differ. Latinx listeners had higher listening demand than European-American listeners. Listening demand differed significantly between sampling weeks and seasons, though the differences were small, and no differences in diversity across weeks or seasons were observed. Larger differences were seen across weekdays, with the highest demand, but lowest diversity, observed on the weekends. Demand varied significantly across the day, with the highest demand observed in the early evening.

Conclusions: Age and location should be carefully considered when interpreting results from or designing studies on auditory ecology. The effects of race, ethnicity, and culture are more equivocal, and more research in this area is needed, particularly with respect to the intersections of race and ethnicity and other demographic and sampling factors. A 1-week sampling period is likely sufficient for valid samples of auditory ecology, and, surprisingly, the season in which data is collected likely has little effect. Studies should, however, balance days of the week. For non-continuous sampling methods, the time of day the data is taken is critical. Significant individual variance was also observed across all studies, raising additional questions about factors affecting auditory ecology and its measurement.

Category: Hearing Loss / Rehabilitation

Poster #: 077 **T35 Research Trainee Poster**

Classroom Listening in Youth with and without Unilateral Hearing Loss

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Objectives: The long-term goal of this research is to develop a questionnaire that captures the listening difficulties of youth with unilateral hearing loss by measuring this group's specific response pattern to various listening situations. This questionnaire assesses ease of listening in school-based situations (e.g., classrooms, cafeterias, gym class). This questionnaire presents several listening situations using pictures and asks the participant to rate how difficult listening is in each situation. Previously, 1148 responses were collected from youth with unilateral hearing loss, and three subscales were developed based on these responses. The objective of the current research was to compare the responses to a classroom listening questionnaire given by youth with normal hearing compared to those previously given by youth with unilateral hearing loss. We hypothesize that youth with normal hearing will rate the listening situations as easier than youth with unilateral hearing loss.

Design: Forty-four youths with self-reported normal hearing bilaterally, aged 9-17 years (mean age = 13.3) were recruited through word of mouth, mass recruitment emails, and flyers. These participants were given a link to complete the questionnaire online.

Results: Prior to analysis, subscale scores were created using the same sub-scale structure used previously with youth with unilateral hearing loss. Specifically, there were three subscales, each corresponding to situations with a talker far away from the listener, a talker near a listener and both inside a building, and a talker near a listener and both outdoors. Cronbach's alpha was used to evaluate the internal reliability of each subscale for youth with normal hearing. The results revealed good internal reliability and were consistent with the findings for youth with unilateral hearing loss. Then, subscale scores were analyzed with linear mixed-effects modeling with subscale (far, near inside, near outside) as a within-participant factor and group (normal hearing, unilateral hearing loss) as a between-participant factor. The scores previously collected from youth with unilateral hearing loss were used in these analyses. Random intercepts for age and participant were also included. Results revealed a significant group by subscale interaction, where differences between groups were larger for the subscales depicting near talkers for the subscale depicting faraway talkers.

Conclusions: These results indicate that youth with normal hearing have less difficulty than youth with unilateral hearing loss in all school-based listening situations depicted. Interestingly, the results suggest that both groups of children find listening to faraway talkers more challenging than listening to nearby talkers, indicating the distance between the speaker and listener may be a significant factor for youth in the classroom whether or not they have symmetrical hearing. Based on the finding that the difference between groups is larger for the subscale depicting nearby talkers indoors, it appears factors such as reverberation and background noise are especially problematic for youth with unilateral hearing loss in classrooms. The pattern of responses for this questionnaire changes between the youth with normal hearing compared to the youth with unilateral hearing loss group. This questionnaire can be useful for evaluating these unique classroom listening challenges for youth with and without hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 078

Factors Limiting Phoneme Discrimination in Cochlear Loss and Auditory Neuropathy

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Objectives: In general, cochlear hearing loss (C-HL) is characterized by poor spectral encoding while auditory neuropathy (AN) is characterized by poor temporal encoding. In adults with normal hearing (NH), degraded temporal cues preferentially impact consonant recognition, while spectral degradations preferentially impact vowel recognition. The link between resolution and phoneme perception is important because the literature supports the idea that consonants facilitate speech recognition and word learning, while vowels preferentially affect recognition of prosody and syntax. Consequently, if children with AN have less access to temporal cues - and therefore many consonant distinctions - they may also have fewer opportunities to develop a strong phonological structure to support speech recognition. This study was designed to (1) assess the acute consequences of spectral and temporal

smearing on vowel and consonant discrimination in school age children with NH, and (2) to evaluate vowel and consonant discrimination in children with AN or C-HL.

Design: Participants include 18 children with NH, 9 children with C-HL, and 4 children with AN. All tests were performed in the sound-field, and children with hearing loss wore their personal hearing aids. Minimal pairs based on vowel and consonant distinctions were presented in the presence of a speech-shaped noise, and the SNR associated with 80% correct performance was estimated. For listeners with NH, stimuli were presented under three conditions: temporally smeared, spectrally smeared, and without smearing. Participants with hearing loss listened in the unsmeared condition only. We evaluated the relationships between vowel and consonant discrimination, phonological awareness, and receptive vocabulary. Additionally, we compared spectral and temporal resolution among all listeners.

Results: Consistent with the adult literature, children with NH demonstrated poorer vowel discrimination for spectrally smeared stimuli and poorer consonant discrimination for temporally smeared stimuli. In general, children with C-HL provided temporal resolution estimates that were similar to their peers with NH, while spectral resolution thresholds were higher than children with NH. For children with AN, most threshold estimates for both temporal and spectral resolution were poorer than children with NH and C-HL. Children with C-HL had more difficulty with vowel discrimination compared to consonant discrimination. While children with AN performed poorly for consonant tasks, they also demonstrated substantial difficulty for vowel discrimination. Phonological awareness and receptive vocabulary were poorer for children with hearing loss than children with NH without clear differences between children with AN and C-HL.

Conclusions: Most published studies cite deficits in temporal resolution as the prevailing cause of poor speech recognition with AN. Importantly, evaluation of frequency resolution in listeners with AN has generally focused on frequency selectivity, not on spectral resolution for complex stimuli. Results from this study would suggest that AN contributes to poor processing of the complex spectral shape cues necessary to distinguish one vowel from another. If this is the case, listeners with AN may be impaired with respect to both temporal and spectral resolution, limiting access to consonant distinctions that facilitate word learning and lexical access and vowel distinctions that signal prosodic and syntactic information.

Category: Hearing Loss / Rehabilitation

Poster #: 079

Psychosocial Profile of Help-Seeking Adults with Hearing Loss

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Objectives: To describe the psychosocial profile of help-seeking middle-aged to older adults with minimal to moderate hearing loss.

Design: 17 participants seeking hearing rehabilitation from an ongoing prospective, single-group, nonrandomized, pre-post clinical intervention study completed a baseline/eligibility session including comprehensive audiological evaluation (including audiometry and speech-in-noise testing using the Words-in-Noise test [WIN]), health and cognition screenings, and questionnaires. The Hearing Handicap Inventory for Adults screening version (HHIA) and the Speech, Spatial, and Qualities of Hearing Scale-Short Form (SSQ12) were collected along with the following psychosocial instruments: Center for Epidemiologic Studies Depression Scale (CES-D), Cohen's Social Network Index (SNI), UCLA Loneliness Scale (UCLA-LS), Positive and Negative Affect Scale (PANAS), the World Health Organization Well Being Index (WHO5), and Vanderbilt Fatigue Scale for Adults (VFS). Results from hearing-specific and psychosocial instruments were compared to published normative data from adults with likely normal hearing. Correlations were performed to evaluate the relationship between the audiological profiles, hearing-specific instruments, and psychosocial instruments.

Results: The mean bilateral pure tone average (PTA.5,1,2,4 k Hz) was 33-dB HL (SD = 7) and participants had a mild to moderate speech-in-noise difficulty (M = 13.1-dB SNR, SD = 4.3). All participants reported mild to moderate hearing handicap measured by the HHIA (total score >8), and clinically significant hearing handicap (>8.5) on the SSQ12. Although participants had positive rather than negative affectivity measured by the PANAS, other instruments of psychosocial wellbeing were more negative. 41% of our participants had a clinically significant depression score captured by the CES-D and 52% had a WHO5 score meeting referral criterion for a depression evaluation. From the UCLA LS, 9 participants reported moderate loneliness, despite 16 participants reporting a diverse social network on the SNI with more than 6 people in their network. The average VFS total score was 58/160 indicating a -0.29 item response theory scale score reflecting mild to moderate listening-related fatigue.PTA had a strong correlation with the HHIA [$r(17) = 0.69$, $p < 0.05$] and UCLA-LS [$r(17) = 0.62$, $p < 0.05$]. WIN was moderately correlated with UCLA-LS [$r(17) = 0.32$, $p > 0.05$]. The SSQ12 showed weak/none correlation with any psychosocial measure, but the HHIA was strongly correlated to the UCLA-LS [$r(17) = 0.70$, $p < 0.05$], WHO5 [$r(17) = 0.62$, $p < 0.05$], and VFS [$r(17) = 0.63$, $p < 0.05$].

Conclusions: The overall profile of our participants seeking hearing rehabilitation services includes the traditional report of clinically significant self-reported handicap (HHIA, SSQ12), mild-to-moderate pure-tone hearing loss with difficulty hearing in background noise (WIN), while interestingly their profile also included poorer self-reported psychosocial wellbeing. Investigations of help-seeking behaviors of adults with hearing loss have largely been focused on audiological factors (degree of hearing loss and speech-in-performance) and self-reported hearing handicap. Results presented here suggest the importance of multiple dimensions of hearing and psychosocial aspects that may also influence help-seeking behaviors. Psychosocial instruments are easy to administer, provide clinical ranges for referrals, and can be utilized along with audiological results to characterize help-seeking adults with hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 080

Evaluating Associations Between Parent and Teacher Versions of Pediatric SSQ

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Objectives: The Outcomes of Children with Hearing Loss Consortium (OCHLCON) is a longitudinal, NIH-funded, multi-center study designed to explore service provision and developmental outcomes of children who are hard of hearing. Within this study, the Speech Spatial and Qualities of Hearing Questionnaire (SSQ) was administered to parents and teachers of children with hearing loss (HL) in first and third grade. The current study examined associations between the parent and teacher scores. Additionally, both the parent and teacher scores were compared to predictor variables: better-ear pure tone average (PTA), better ear speech intelligibility index (SII) at soft speech and conversational speech levels; and outcome variables: BKB SNR or Az Bio in noise percent correct.

Design: Ninety-eight pairs of parents and teachers completed the SSQ questionnaire for children with HL (45 in first grade and 53 in third grade). Neither parents nor teachers were given explicit instructions to observe the child for a set period before completing the questionnaire. Additionally, children were administered a test battery that assessed better-ear PTA, better ear SII at 50 dB SPL (soft speech), or 65 dB SPL (conversational speech), BKB SNR, and Az Bio in noise. We conducted a correlational analysis to explore the relationship between the parent and teacher scores by grade level on the SSQ. Additionally, we conducted a correlational analysis to evaluate the association between parent and teacher scores and predictor and outcome measures.

Results: In the three sections of the SSQ (speech, spatial, qualities) at both grades, there were strong associations within the parents and teachers (all p-values< .001) but no associations between parents and teachers. Parent scores were not associated with predictors (better-ear PTA, better ear SII at 50 or 65 dB SPL) or outcomes (BKB SNR or Az Bio in noise percent correct) at either grade. Teacher SSQ scores were significantly correlated with BKB SIN ($r = -.465$, $p = .001$) at first-grade. At the third-grade level, teacher SSQ scores were significantly correlated with BKB SIN ($r = -.277$, $p = .045$), AZ bio in noise ($r = .325$, $p < .001$), better ear SII at 50 dB SPL ($r = .318$, $p = .03$), and better ear SII at 65 dB ($r = .393$, $p = .007$). Unaided hearing (BEPTA) was not correlated with the third-grade teacher report, demonstrating that teachers are likely making judgements based off the children's hearing when wearing their hearing aids.

Conclusions: Teacher data was associated with a variety of predictor and outcome measures at both first and third grade, whereas parents did not show any associations between such measures. Additionally, we found a greater number of significant correlations between third grade teacher scores and predictor and outcome measures than first grade scores. Because of the nature of the questions on the test, it is possible that teachers had more ecologically similar situations in which they were observing the children.

Category: Hearing Loss / Rehabilitation

Poster #: 081

Hearing Loss Impacts Perceptions of Providers and Satisfaction with Care

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Objectives: Recent literature has highlighted hearing loss (HL) as a potentially modifiable public health concern. Research also revealed that those with HL interact differently within health care systems. Over a ten-year period, patients with HL spent 46% more on care, had a higher 30-day readmission rate, and experienced more inpatient hospital stays. Patients with HL are also more likely to give lower ratings of overall healthcare satisfaction. These negative perceptions may be related to the impacts of HL on communication of important health information. Miscommunication can contribute to increases in adverse clinical events, while effective communication has been linked to improved health outcomes. Findings suggest that communication barriers exist for patients who have HL and could serve as a source of challenges experienced within the healthcare system. Although dissatisfaction with overall healthcare for those with HL has been well-documented, there remains a lack of understanding of how these patients perceive interactions with providers and characterize providers' attitudes towards them. OBJECTIVES: The primary objective of this study was to explore the perceptions of provider interactions among Medicare beneficiaries with and without hearing difficulty. It was hypothesized that patients reporting HL would be more likely to provide poorer ratings of provider interactions, and ratings would be poorer for those who reported greater hearing difficulty.

Design: This cross-sectional study used information from 12,171 interviews completed through the 2016 Medicare Current Beneficiary Survey (MCBS), including only individuals older than 65. Patient Reported Outcomes (PROs) were used to characterize perceptions of interactions and relationships with their regular physicians through a series of 10 statements such as, "The doctor or other health professional is competent and well-trained." Individuals with HL were identified through the MCBS self-reported functional hearing question ("no trouble", "little trouble", "a lot of trouble"). Ordinal logistic regression adjusted for age, sex, race, education, income, marital status, and comorbidity count was used to assess the association of hearing difficulty and perceptions of providers.

Results: Of the weighted sample, 39.32% reported having a little and 5.7% reported a lot of trouble hearing. Adjusted ordinal models revealed a trend such that hearing difficulty was associated with poorer perceptions of providers. Specific examples include those with a little hearing difficulty having lower odds of disagreeing with negative statements such as "provider seems to be in a hurry" (Odds Ratio [OR]=0.806; 95% Confidence Interval [CI]=0.737-0.880) relative to those without hearing difficulty. These individuals also had higher odds of disagreeing with positive statements such as "provider answers all questions" (OR=1.177; 95%CI=1.060-1.472) relative to those without hearing difficulty.

Conclusions: In a nationally representative sample of Medicare beneficiaries over 65, hearing difficulty was associated with higher odds of reporting negative perceptions of interactions with healthcare

providers. These results are limited by potential recall bias and self-report measures. Understanding the perceptions of patients with HL may provide information regarding specific aspects of care that contribute to negative perceptions, and direct further efforts to improve patient satisfaction. This is important because greater healthcare satisfaction is associated with improved healthcare outcomes for patients with HL.

HEARING SCIENCE / PSYCHOACOUSTICS

Category: Hearing Science / Psychoacoustic

Poster #: 082

Immature Sound Localization Ability of Toddlers in Complex Listening Condition

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Objectives: The precedence effect (PE) is phenomenon by which the auditory system assigns greater perceptual weight to the leading than lagging sound; however, when the PE is weak, spatial cues carried by the lag can reduce accuracy with which the direct source is localized. The PE matures during childhood, when establishment of accurate spatial hearing skills is paramount to a child's ability to navigate in everyday, reverberant environments. Left-right discrimination of the lead is worsened by the presence of the lag, more so at age 5 years than in adults, and further worse in toddlers. Because left-right discrimination does not provide information regarding localization, we investigated how the PE operates in toddlers using a 'reaching for sound' localization approach. We previously showed that toddlers can localize single-source (SS) sounds with great accuracy: root-mean-square (RMS) errors near 10^0. Here we adapted this approach to the PE and compared to localization of SS stimuli.

Design: Participants included 16 typically-hearing toddlers, mean age 34.8 months (range 25-44). The experiment was carried out in two separate sessions, with the SS condition during the first session and PE conditions during the second session. The testing apparatus was a semi-circular arc covered by a curtain. Nine holes in the curtain, spaced 15^0 apart spanning -60^0 to 60^0 azimuth, each had a loudspeaker behind. On each trial, the task was to reach inside a hole towards the sound at the perceived location. SS stimuli consisted of a recorded female voice (60+/- 4 dB SPL) saying the carrier phrase "I'm hiding under..." presented at 0^0, followed by 3 white noise bursts from 1 of 9 loudspeakers. PE stimuli began with the carrier phrase; then for noise bursts the lag was at 0^0 and lead was at one of the other 8 loudspeakers. The delay was 5 ms, and the lag level was 60 dB SPL (same as lead, PE60-60) or 50 dB SPL (PE60-50 condition). RMS error was calculated for each participant and condition.

Results: RMS errors, evaluated for mean (±SD) and range, were 8.53^0 ($\pm 8.99^0$) range 0^0 to 36.55^0; 9.72^0 ($\pm 8.94^0$), range 0^0 to 38.11^0; and 13.13^0 ($\pm 8.52^0$), range 6.49^0 to 42.20^0, for the SS, PE60-50 and PE60-60 conditions, respectively. A one-way repeated measures ANOVA showed no statistically significant differences ($p > 0.05$) between the 3 conditions, likely due to large variability in participants' errors.

Conclusions: This was the first study to investigate localization in toddlers using the PE paradigm, with the 'reaching for sound' approach. We found that localization errors vary across participants, such that some show minimal increased errors while others show large increased errors in the presence of the lag. This is particularly true for the most challenging condition with the lagging stimulus presented at the same level as the lead. RMS errors were higher than errors shown previously in 4-5-year old children, when tested using a 5ms lead-lag delay. Further research is needed to fully understand the impact of echoes on localization abilities of children and maturation of these abilities during childhood.

Category: Hearing Science / Psychoacoustics

Poster #: 083 **Mentored Student Research Poster Award**

Interplay Between Intonation Perception and Speech Emotion Recognition

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Objectives: The ability to accurately perceive and recognize emotions from speech is a fundamental aspect of human communication. Perceiving emotions from speech involves the analysis of vocal prosody, especially intonation. When variations in intonation are challenging to track, listeners might resort to other cues, like facial expressions or context, to interpret emotions, but these may not always be available or reliable. For older adults, the ability to track variations in Intonation may be compromised due to hearing loss, aging, or changes to cognitive abilities, which might lead them to misinterpret emotions in speech. The primary objective of this study is to investigate whether there exists a significant correlation between the ability to perceive intonation and the ability to recognize speech emotion in older adults. It was posited that older listeners with impaired ability to perceive variations in Intonation may make emotion perception ‘mistakes’ that have communication consequences.

Design: A group of older adults with hearing thresholds ranging from normal to mild-moderate hearing loss participated in this experiment conducted in a single 2-hour session. The first task investigated intonation perception using synthesized diphthongs spoken by a male and female talker in which fundamental frequencies varied from strongly rising to strongly falling. A two-alternative forced-choice paradigm was employed to measure participants' ability to identify dynamic pitch changes. The second task focused on the recognition of vocal emotion using emotion-neutral sentences naturally spoken by a male and female talker, expressing five emotions (happy, sad, scared, angry, neutral). Both tasks utilized signals generated from a custom MATLAB program. Listeners were seated in a sound-treated room with speakers positioned 1 meter away and at ear level, at an azimuth of 0 degrees. Testing was conducted in a sound field with signal presentation level calibrated to a default play out of 69 dB SPL and accounted for participants' individual hearing thresholds by adjusting for increased volume for both tasks. Response metrics included identification accuracy for pitch direction and emotion, and reaction time.

Results: Findings show that better Intonation perception scores were associated with better speech emotion recognition scores. Also, there appeared to be negative associations between age and intonation perception as well as between age and speech emotion recognition.

Conclusions: The observed results present evidence that individuals who are better at deciphering Intonation in speech (involving relatively simple changes in fundamental frequency) will be better at recognizing emotions in speech that involve more complex changes in fundamental frequency. From a clinical perspective, these findings may inform the design of rehabilitation strategies to specifically enhance Intonation cues to improve speech emotion recognition

Category: Hearing Science / Psychoacoustics

Poster #: 084

Objective and Subjective Effects of Gamification with Long Adaptive Tracks

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Objectives: The addition of game elements into experimental tasks, or "gamification," may be a means of increasing participant engagement, enjoyment, and performance with speech-in-noise testing. Previously, a gamified version of the Spatial Release from Masking (SRM) test showed comparable estimates of performance to the traditional test over short testing durations. However, participants continued playing the gamified test until the natural conclusion of the game, and their performance continued to improve over time. The purpose of this study was to compare a traditional and gamified version of the SRM test over long testing durations to determine if gamification yields better performance, faster rates of task learning, or both. Additionally, subjective reports of effort, enjoyment, frustration, and perceived success were collected to provide insight into the user experience with the traditional and gamified test.

Design: Thirty-four adults (aged 20-47 years) with normal hearing completed a traditional laboratory and gamified version of the SRM test in a counterbalanced order. Both tests used target and masker sentences from the Coordinate Response Measure corpus. Target and masker positions were simulated over headphones to be either colocated or spatially separated. In the traditional test, participants responded on a simple grid of closed set response options with no other visual elements. In the gamified test, participants responded on a gamified board designed with the theme of a spaceship race. Correct responses made their ship go faster and revealed a pattern of game pieces that formed a path across the board. Both tests adapted the target-to-masker ratio based on performance with a one-up-one-down adaptive algorithm that ran for 30 reversals. Data were used to estimate 50% correct thresholds and determine the minimum number of trials required for accurate estimation of the psychometric function for colocated and separated maskers on each test. Subjective ratings of effort, enjoyment, frustration, and

perceived success for each test were compared to contextualize the performance data and characterize the participant experience.

Results: Behavioral data indicate a small improvement in performance associated with gamification. Evaluating the number of trials required to estimate the psychometric function will determine if gamification produces these results with the same or different number of trials. Subjective reports indicated that participants experienced more frustration and less success in the gamified test than the traditional test. This effect may have been driven by a propensity for participants to lose race when the speech task was close to their performance threshold.

Conclusions: Results will be discussed in terms of the potential advantages of gamification for accurately and efficiently measuring performance on the SRM task. Subjective ratings revealed that listeners' perception of success and frustration may have been biased by the outcome of the game, rather than the difficulty of the underlying speech task (identical for both tests). This finding suggests that designing the game such that participants win the game often may lower rates of frustration and increase perceived success even for a challenging speech-in-noise task.

Category: Hearing Science / Psychoacoustics

Poster #: 085

WITHDRAWN

Category: Hearing Science / Psychoacoustics

Poster #: 086

Effects of Head Movement on Spatial Release from Masking Task

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Objectives: Head orientation is considered a key factor in enhancing speech intelligibility in environments with spatially distributed sound sources. Recently, there has been an increasing interest in utilizing head movement data to enhance hearing aid algorithms. Yet, in most studies on speech perception and spatial hearing, the head is typically restricted to directly in front of the listener or towards a specific direction. Furthermore, the benefits and deficits resulting from natural head movement in a moving masker condition, which is realistic during conversation, have rarely been explored. The aim of this study is to investigate the impact of natural head movements on functional spatial boundaries, which are defined as the necessary spatial separation for effectively segregating competing speech. Additionally, the study aims to identify head movement strategies and how these movements contribute to or hinder spatial release from masking. We hypothesize that an optimal head orientation exists between a target and masker which would improve spatial boundaries compared to when the head is fixed to the front.

Design: Twenty-one young normal hearing listeners aged 18-38 were recruited. This study used a modified spatial release from masking (SRM) task that adaptively measured the spatial separation angle needed between a continuous male target speech stream and two symmetrically lateralized female masker speech streams to achieve a specific SRM. In a co-located condition from the front (0° azimuth), individual thresholds in dB target-to-masker ratio (TMR) were evaluated. Based on that TMR-threshold, the individual spatial boundary thresholds for 6 dB and 9 dB release from masking with babble present were measured. These tests were performed under two conditions: one with the head fixed facing forward, and the other allowing (and encouraging) free head movement, as much as desired for better segregation of the target speech. Head movement was tracked with a video camera and measured offline using face recognition software to quantify head rotation angle in yaw, roll, and pitch.

Results: There were no significant differences in the dB TMR thresholds and spatial boundary thresholds for both 6 dB and 9 dB release from masking, when comparing the head-fixed and head-free conditions. Additionally, no significant correlation was observed between head movements (yaw, roll, and pitch) and spatial boundary thresholds for both 6 and 9 dB SRM. However, a significant correlation was observed between head rotation in the roll axis and dB TMR thresholds. Natural head movements did not show notable variations between the 6 and 9 dB SRM conditions. While there was high inter-subject variability of difference in spatial boundary thresholds between the head-fixed and head-free conditions, no relationship was found with any specific type of head movement.

Conclusions: This study suggests that natural head movements away from the target speaker may not provide any significant advantages in this symmetrical-masker paradigm, but may provide a disadvantage for speech segregation during conversations with moving maskers as compared to when their head is kept oriented to the front target talker. This data on natural head movements would be fundamental to improving hearing aid beamforming algorithms that utilize head position.

Category: Hearing Science / Psychoacoustics

Poster #: 087

Effects of Ear Canal Geometry on Wideband Acoustic Immittance Measurements

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Objectives: This study investigates the impact of individual ear canal geometries on wideband acoustic immittance (WAI) measurements. WAI measurement approaches generally assume a uniform cylindrical ear canal where all reflections occur at the tympanic membrane and more medial positions, resulting in the assumption that canal geometry does not affect the measured absorbance. However, normal-hearing ears exhibit variability in absorbance that might result partially from the canal geometry. Here, we systematically measure how absorbance varies in canals of different geometries and ages. The primary objective is to determine the extent to which ear canal geometry influences absorbance.

Design: The experimental design uses computed tomography (CT) scans, radiology software, and 3D modeling software to print 3D ear canal models of real human ears. These 3D-printed canals are

connected to an artificial ear that couples directly to the canal and has impedance characteristics that match the industry-standard Larson-Davis artificial ear. This setup ensures that variations in WAI measures are attributed solely to differences in canal geometry rather than characteristics specific to the terminating middle-ear impedance. Measurements are made with two FDA-approved systems: HearID (Mimosa Acoustics) and Titan (Interacoustics). WAI measurements are made at multiple canal locations within a few mm of the first bend, and quarter wavelength resonances are used to confirm the probe's location.

Results: Absorbance was measured at several locations in the cylindrical canal and in 3D-printed canals from CT scans of ears that are both relatively straight and quite curvy. The absorbance measured in the cylindrical canal is nearly independent of measurement location, with the largest differences on the order of about 0.05 near 2000 Hz. Absorbances measured in the 3D-printed human canals at plus-and-minus 2-3mm from the first bend show variable differences with location across subjects. Case studies will be presented to demonstrate the range of differences in absorbances measured with HearID and Titan in canals of different shapes.

Conclusions: Contrary to the assumption that absorbance is independent of canal geometry, our findings suggest that some canal shapes lead to greater variations with location in absorbance measurements than with a straight cylinder. Canals with slowly changing areas and cylindrical shapes seem to exhibit less variability in absorbance than canals that have more curvature or variations in area. It appears that canal geometry might play a role in the variability of absorbance measurements in normal-hearing ears.

Category: Hearing Science / Psychoacoustics

Poster #: 088 **T35 Research Trainee Poster**

Neural Mechanisms Underlying Speech-in-Noise Processing in Children and Adolescents

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Objectives: In this study, we aimed to investigate the underlying neural mechanisms that contribute to speech-on-speech and speech-in-noise abilities in children using magnetoencephalography (MEG). We hypothesized that 1) as age increases, speech-to-noise ratio will decrease in both two-talker and speech-shaped noise, but that these effects will be greater in the two-talker condition and 2) children will exhibit greater language-related neural activity in two-talker masker than speech-shaped noise.

Design: A total of 66 normal-hearing, typically-developing youth aged 7-15 years were recruited for the study. Experiment 1 consisted of a speech-in-noise task to determine the signal-to-noise ratio that yielded 70% intelligibility (SNR-70) for a speech-shaped noise and a two-talker masker. These thresholds were then used in Experiment 2, which was a fixed-threshold speech-in-noise task during MEG. Each

participant's MEG data was co-registered to their structural MRI, preprocessed, and transformed into the time-frequency domain. Significant oscillatory responses, both to pre-target noise and to target + noise, were independently imaged using beamforming. These source images were then subjected to a whole-brain repeated-measures ANOVA with noise condition (speech-shaped noise vs. two-talker) as a within-subjects variable, age as a covariate of interest, and SNR-70 as a covariate of no interest. Whole-brain statistics were performed on each neural response independently and corrected for multiple comparisons at $p<.001$ with a cluster-based correction of $k=6$ voxels.

Results: In Experiment 1, we found significant main effects of task and age, such that SNR-70 was higher in the two-talker compared to the speech-shaped noise, and SNR-70 improved across both conditions as a function of age. We also found a significant condition-by-age interaction, such that age-related SNR-70 improvement was larger in the two-talker condition relative to the speech-shaped noise condition. In Experiment 2, we found distinct neural patterns of alpha (9-12 Hz) and beta (16-24 Hz) activity in both occipital and language-related regions during noise processing and target+noise processing. Whole-brain repeated-measures ANOVA results indicated significant beta condition-by-age interactions during target+noise processing in the right articulatory motor cortex and posterior inferior parietal lobule. Post-hoc testing found that, controlling for SNR-70, there was a stronger decrease in beta power as a function of age in these regions in the two-talker condition, while there were no significant age effects in these regions during the speech-shaped noise condition. Importantly, the difference in beta activity in the inferior parietal lobule between conditions significantly mediated the relationship between age and SNR-70 conditional differences. Taken together, these data suggest that beta neural dynamics are related to improvements in speech-on-speech abilities in youth.

Conclusions: In this study, we found that as age increases, there is a larger decrease in SNR-70 during a two-talker masker than during speech-shaped noise, suggesting differential developmental patterns, and that these improvements in understanding in speech-on-speech abilities are served by decreases in beta power in right articulatory motor and posterior inferior parietal regions. These data provide insights on the neural processes serving developmental improvements in speech-on-speech abilities. In the future, we plan on investigating the impact of mild-to-severe hearing loss on these behavioral and neural processes.

Category: Hearing Science / Psychoacoustics

Poster #: 089

The Impact of Acute Impairment on Adaptive Head Movements in Individuals with Single-Sided Hearing Loss

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Objectives: Single-sided deafness (SSD) is a condition where one ear has no functional hearing while the other ear has normal hearing. Research has shown that individuals with single-sided deafness struggle with localizing sounds and understanding speech in the presence of background noise. Though some studies have highlighted the importance of limited auditory deprivation on speech outcomes, it remains poorly understood how duration of deafness or ongoing auditory stimulation may impact these abilities. It is also unclear how adaptive listening strategies may play a role in performance on binaural tasks as most current test paradigms require fixed head positioning and limit an individual's ability to utilize head movement adaptations to assist with listening. Here, we aim to characterize and compare head movement patterns during a combined localization and speech-in-noise task for individuals with longstanding organic SSD to those with acute conductive hearing loss from ear plugging to better understand how adaptive behaviors emerge.

Design: Normal hearing subjects were tested in an un-occluded (NH-UO) and occluded condition (NH-O), with the latter facilitated by placement of a deeply seated earplug and over-the-ear muff, and SSD subjects were tested in an unaided condition alone. Broadband noise (BBN), narrowband noise (NBN), and speech-in-noise (SIN) stimuli were presented in a hemi-anechoic chamber using 24 speakers, evenly spaced 15o apart, spanning 360 o around the subject. For the localization only tasks (BBN, NBN), subjects indicated the perceived location of the stimuli with a button push, and for the combined task (SIN), subjects repeated the target stimuli (Harvard IEEE sentences) in addition to indicating perceived stimulus location. A head-position tracker captured real-time movement throughout the task.

Results: For localization only and combined tasks, head movement analysis will quantify movement delay (ms), absolute total displacement (degrees), and total response time (ms). Localization accuracy will be calculated as root-mean-square error and linear best-fit characteristics across target locations. Combined task SIN performance will be characterized as psychometric functions of percent correct according to stimulus signal-to-noise ratio. Data from all analyses will be compared between groups (NH-UO, NH-O, and SSD) and stimulus conditions (BBN, NBN, SIN).

Conclusions: Data presented here will provide valuable insight into the adaptation of localization and speech understanding for individuals with SSD. While only an initial investigation of the acute effects of hearing impairment on adaptive head movement, this is a first step towards developing a better understanding of what adaptive strategies are employed and how they are developed in individuals with SSD.

Category: Hearing Science / Psychoacoustics

Poster #: 090

Establishment of Equivalent Air Conduction and Electrical Pure Tone Thresholds

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Objectives: The conventional transmission of sound is through air and bone conduction. Acoustic receivers and bone conduction transducers offer the capability to enhance hearing for a variety of uses in the world of sound. However, there is another approach to create the perception of sound that is largely ignored despite its notable and unique capabilities. Auditory electrostimulation has been known since the early 1800's when it was shown that electrical energy fields applied to the skin could create the perception of sound. Noninvasive electrostimulation of the cochlea using surface electrodes is being investigated as a means to establish standard reference levels of electrical thresholds as a platform for more advanced research regarding improvement of the fidelity and lateralization of sound. A novel headset was created for this study, the Mayo Clinic Cochlear Stimulator Headset, with four electrode channels. The objective was to establish reference levels in dBHL and milliamps (mA) for air conduction thresholds and electrical auditory thresholds at three locations on the head for frequencies from 0.25-20 kHz.

Design: 20 participants (10 male, 10 female) between the ages of 21 and 55 completed this study. They had normal hearing binaurally, verified by the pure-tone hearing test they completed using the Madsen Astera with ER-3A insert earphones for frequencies from 0.25-8 kHz. Extended high frequencies of 10-20 kHz were tested with circumaural phones, for both right and left ears as well as binaurally. Using the Mayo Clinic Cochlear Stimulator Headset, three channels of mylar electrodes were placed on the forehead, mastoid processes, and nape of the neck. Two electrodes, cathode and anode, make up one channel. Each electrode channel has an individualized carrier frequency, dependent on skin conductance. The same frequencies tested for air conduction thresholds were tested electrically with steady-state pure tones. A descending method, decreasing in increments of 0.5 mA and then increasing in increments of 0.2 mA was used to find the participant's thresholds at each frequency. Voltage (V), while a moving target, was recorded for every threshold at each frequency, and no electrode channel could have a voltage greater than 3.3 V as a safety measure.

Results: When the graphs were plotted for the electrical stimulation needed at each location on the head to reach auditory threshold, their respective shapes followed the curves of the air conduction threshold levels. Regression and correlation analyses were completed for electrical and acoustic thresholds at each frequency. A graph will display levels of current in mA obtained for frequencies in octave intervals between 250Hz and 20,000 Hz. It is important to note that underpinning the electrical thresholds established were participant specific resonance values that ensure optimal interface between skin to electrode.

Conclusions: The present study showed that equivalency can be established for auditory and electrical thresholds of hearing and relates to long-established reference levels.

Category: Hearing Science / Psychoacoustics

Poster #: 091

Perceived Quality of Hearing-Aid Processed Audios: A Multi-Dimensional Scaling Study

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Objectives: This research addresses the perceptual effects of advanced hearing aid features, with a focus on Wide Dynamic Range Compression (WDRC) and Noise Reduction (NR), under high and low signal-to-noise (SNR) conditions. These effects, inherently unobservable, demand inference from listeners' responses when asked to judge the quality of hearing-aid processed audios. Our primary aim is to investigate the listener's perceptual dimensions associated with device features and background SNR using a multidimensional scaling (MDS) experiment.

Design: Recordings were made in the ear canal of a Knowles Electronics Manikin for Acoustic Research (KEMAR) while wearing a ReSound LiNX Quattro 62 hearing aid in response to a speech-in-noise stimulus presented in front of the KEMAR at 65 dB (A). The stimuli consisted of Connected Speech Test (CST) sentences. The Noise comprised 20-talker babble noise presented at 0- and 10-dB SNR. Amplification was applied according to the NAL-NL2 prescription formula for 3 typical audiograms: flat moderate, flat severe, and steep sloping moderate to severe. The Noise Reduction (NR) algorithm was either turned on ("Strong") or off, while all other technological options were disabled. Accordingly, there were a total of 12 recording conditions. These recordings were used as the stimuli in a multidimensional scaling experiment, in which participants rated the similarity between two audio samples between 0 and 100, with 0 representing "no difference" and 100 indicating "maximum difference". The two audios on each trial were the same 3-second excerpt from the recordings but, in a majority of cases, under two different recording conditions. The participant could replay the audios as many times as needed. A group of young, normal-hearing participants were recruited for the experiment, which consisted of a practice block to familiarize the participants with the task, followed by two experimental blocks. Each experimental block contained all 66 unique pairs from the combinations of the 12 recording conditions and four additional "catch trials" with the pair of audios being identical. For each participant, the similarity ratings collected during the experiment were used to make inferences of the underlying perceptual dimensions for the 12 recording conditions using an MDS algorithm. An objective metric of speech quality, the Hearing Aid Speech Quality Index (HASQI), was computed for each recording, and an MDS analysis was performed on the difference in the HASQI scores between pairs of recording conditions.

Results: For a majority of participants, the projection of SNR and NR in the derived perceptual space does not align in the perceptual space. When the same analysis is done with HASQI scores, the effects of SNR and NR were generally along a single perceptual dimension.

Conclusions: The results suggest that switching on the NR algorithm seemed to be not perceptually equivalent to increasing the SNR for most listeners. Although the performance of NR algorithms is often quantified as the improvement in SNR, their perceived effects are quite different from simply increasing SNR.

HEARING TECHNOLOGY / AMPLIFICATION

Category: Hearing Technology / Amplification

Poster #: 092

Comparisons Between Hearing Aid and Wrist-Worn Step Counters

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Objectives: Integrated motion sensors (accelerometers) in hearing aids were developed to assist classification. Worn at ear level, the accelerometer can function as an accurate step counter. In this study, we addressed the following questions:1. Does the hearing aid step counter provide an accurate (or more accurate) step count compared to wrist-worn step counters when the wearer is walking?2. Does the hearing aid step counter provide a more accurate step count compared to wrist-worn step counters in activities involving arm and body movements but no steps?3. Do false step counts, due to arm movements, result in lower (but more accurate) step counts in real life for the hearing aid step counter compared to wrist-worn step counters?

Design: Ten participants (four male, six female) with normal hearing and a mean age of 45 years were recruited to compare the hearing aid step counter with two commercially available wrist-worn step counters.Five tasks were designed to compare the accuracy of the step counters. Participants were asked to wear their hearing aids on their ears and both wrist-worn devices on the same arm.Task A: Walking 200 steps at a normal walking paceTask B: Walking up/down 200 stairsTask C: Loading/unloading a dishwasher while keeping feet stationaryTask D: Placing/removing items between countertop and a shelf at head level while remaining stationaryTaskE: Daily activities. Participants were asked to wear the hearing aids and wrist-worn devices during daily activities

Results: Task A. All mean values were within four steps of the true count, and analysis of the data using a mixed model ANOVA showed no significant effect of device type ($p = .13$).Task B. All mean values were within 20 steps of the true count, with no statistically significant differences between the mean values, according to a mixed model ANOVA ($p = .56$).Tasks C and D. The hearing aid step-counter made no (false) detections of steps, resulting in a mean step count of zero. A Wilcoxon matched pairs test showed the mean counts made by the two wrist-worn devices were significantly higher (Task C, 79 and 58 steps; Task D, 83 and 31 steps) than the hearing aid step counter in both tasks (all $p < .05$).Task E. The mean step counts made by the wrist-worn devices were higher than the mean count made by the hearing aid step counter. The differences were statistically significant, according to a mixed model ANOVA and Tukey HSD post-hoc test ($p = .03$ and $p = .002$).

Conclusions: The hearing aid step counter and wrist worn step counters were expectedly consistent for walking tasks. However, for stationary tasks, the wrist-worn devices registered arm movements as steps, whereas the hearing aid step counter did not register false steps. For the home trial, the hearing aid step counter registered fewer steps than the wrist-worn devices, suggesting that the wrist-worn devices are likely to register additional false steps. The accuracy of the hearing aid step counters should be considered to assist hearing aid wearers in health monitoring.

Category: Hearing Technology / Amplification

Poster #: 093

Changes in Brain and Behavioral Measures with Hearing Aid Use

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Objectives: Hearing aid acclimatization, or changes in brain and behavioral measures over time, has been reported by patients and clinicians; however, the scientific literature is mixed with some studies demonstrating acclimatization in some individuals but not in others. Differences across studies and individuals may be due in part to differences in outcome measures, sensitivity of measures, and/or groups tested. The goal of this study was to determine which outcome measures were most sensitive to short-term audibility and long-term acclimatization changes among new hearing aid users. Study outcome measures included various subjective and objective tests including auditory evoked potentials, speech-in-noise tests, and tinnitus/effort questionnaires. We hypothesized that outcome measures would vary in their sensitivity to audibility and acclimatization effects depending on their ability to measure more bottom-up sensation changes or more top-down perception abilities.

Design: New hearing aid users in the VA Portland Healthcare System (preliminary data n=20) were followed longitudinally for 6-7 months. Participants were tested twice pre-hearing aid fitting to approximate test-retest effect sizes for the outcome measures (Visit 1 & 2), within a week of the hearing aid fitting (Visit 3), 1-2 months post-fitting (Visit 4), and 4-6 months post-fitting (Visit 5). Test-retest effects were derived from a comparison between Visit 1 and Visit 2. Audibility effects of the hearing aids were derived from a comparison between Visit 2 & Visit 3. Acclimatization effects over time were derived from a comparison between Visit 3 and Visit 4/5. This longitudinal study used three categories of outcome measures to extract possible objective and subjective changes in audibility and acclimatization: cortical and cognitive auditory evoked potentials, speech-in-noise tests, and questionnaires.

Results: The test-retest of outcome measures was generally good across measures. Preliminary data demonstrate robust audibility effects and modest acclimatization effects for some measures. The specific effects across outcomes measures will be presented and discussed.

Conclusions: Test-retest, audibility, and acclimatization effects vary depending on the specific outcome measure. The best measure to demonstrate effects depends on the specific effect of interest and whether the underlying cause is primarily a bottom-up or top-down phenomenon. This research may lead to a better rehabilitation and treatment strategies to improve hearing aid benefit in new hearing aid users.
(This study was supported by VA-RR&D 5I01RX003702).

Category: Hearing Technology / Amplification

Poster #: 094

Multi-Curve Frequency Response Characteristics of Hearing Aid Music Programs

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Objectives: This study aims to posit user-friendly, qualitative differences between the frequency responses of hearing-aid music programs to help guide fitting decisions.

Design: For testing, flagship receiver-in-the-canal hearing aids were selected across four manufacturers: the Widex Moment Sheer 440 sRIC R D, Oticon Real 1 miniRITE R, ReSound Nexia 960S-DRWC, and Phonak Lumity L90-R. Prior to testing, a music-weighted stimulus was created. Twelve songs that spanned multiple genres, musical periods, and languages were placed into Studio One 6 (a digital-audio workstation). Each song was trimmed to a length of two minutes and thirty seconds in order to avoid potential biases of only recording certain sections. Each snippet was placed in its own track, and was volume-adjusted to allow for maximum output without causing peak clipping. On the master track, Voxengo Curve EQ (a frequency analyzer/recorder plugin) was activated. The frequency response from all twelve snippets was recorded and averaged. The output from a white noise-generator plugin was also recorded. The frequency response from the song snippets was superimposed onto the white noise by Curve EQ in order to create a stimulus that is spectrally-representative of music.The music stimulus was used in the Speechmap protocol of the Verifit 2 test box at 50, 60, 70, and 80 dB SPL outputs. All four hearing aids were tested with two different hearing losses: 0 dB flat hearing loss, and the N3 audiogram as established by Bisgaard, Vlaming, and Dahlquist (2010). Under these conditions, frequency response curves were yielded, each reflecting how the hearing aids altered the frequency characteristics of the music stimulus. These results are compared to a control trail where the music stimulus was captured in absence of a hearing aid.

Results: The primary findings of each hearing aid's spectral analysis were as follows: the Widex Moments had the highest overall gain, with noticeable spectral peaks centered around 350 and 7000 Hz, the ReSound Nexias closely resemble the test stimulus without a 2cc coupler, the Oticon Reals featured a 10 dB increase in gain from 2000 Hz and above, and the Phonak Lumities featured increased compression in low frequencies.

Conclusions: Music programs are designed to improve music appreciation for individuals with hearing loss. The method and subsequent output for these programs varies among manufacturers. Patients may benefit from specific devices depending on their specific needs. Understanding how these programs alter the output of the hearing aid allows the audiologist to better guide the patient with music appreciation needs.

Category: Hearing Technology / Amplification

Poster #: 095

An Investigation of Two Methods for Comparing Hearing-Aid Settings during Group Conversations

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Objectives: Communication in complex situations is among the most difficult situations that people with hearing loss commonly encounter. Hearing-aid function in these situations is, therefore, one of the most important challenges to focus on within the hearing-aid industry today. Still, there is currently a lack of methods that specifically and systematically measure hearing-aid function while the user is performing tasks such as having live conversations. In the current project, the aim was to develop an outcome measure for the auditory utility of hearing-aid settings in live group conversations. More specifically, we compared two possible ways of implementing paired comparisons of hearing-aid settings with the goal of finding out which of the two (if any) was better in the context of live group conversations.

Design: 27 older experienced hearing-aid users with moderate hearing loss met in groups of three. They were recruited from the ORCA Europe test participant database. They had previously been fitted bilaterally with Signia Pure 312 7X M RITE hearing aids according to the first-fit suggestion from the manufacturer. Two different directionality settings were implemented as separate programs in the hearing aids. Two conversation scenarios were then staged in an ordinary office setting using four corner loudspeakers: one relatively quiet scenario (45 dB(A)), and one in restaurant background noise (67 dB(A)). Consensus questions were used to spark 4-minute conversations between the three interlocutors. Two different procedures were implemented during the conversations. Participants were asked to either toggle between the two programs individually during the conversation, or the test leader set a fixed program for the conversation and the participants' only task was to converse. After each conversation, the participants rated hearing-aid function, ease to hear and speak, and the flow of the conversations, by filling in a questionnaire using a tablet. Whenever participants had toggled between the two programs, they were asked to complete the ratings for their preferred program. We refer to these two different procedures as a "paired comparison" method, when participants toggled between the two programs, and a "ratings" method, when participants listened to a fixed program. Each group of participants completed two sessions of each conversation scenario, with paired comparisons and ratings so that we could investigate the test-retest reliability of the two methods.

Results: Preliminary data analyses showed that both the paired comparison and the rating methods were feasible. The live conversations did not seem to impact the participants' ability to perform paired comparisons and, vice versa, the toggling between the programs did not seem to affect the conversations. Both methods showed higher ratings overall for one of the two hearing-aid programs, suggesting that one of the two programs was clearly preferred by most participants.

Conclusions: Recommending one method over the other is a complicated matter, as detailed consideration of the differences between ratings for the two programs suggests that both methods have their pros and cons. The detail of these differences and their implications for choosing one method will be discussed in our presentation.

Category: Hearing Technology / Amplification

Poster #: 096

Impact of Hearing Aid Processing Delay on Stop Consonant Voicing Perception

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Objectives: Hearing aid (HA) processing delay, defined as the time interval between the acoustic signal arriving at the HA microphones and the processed signal played through the receiver, creates distortions in open fit digital hearing aids via mixing of the original unamplified sound and the delayed processed sound at the ear drum. In the frequency domain this creates an audible metallic sounding artifact known as comb-filtering. In the time domain, the delay creates asynchronous doubling of the sound, that can shift and smear the temporal cues. We hypothesized that such temporal distortions could degrade stop consonant perception through overlap of energy of a preceding consonant on the following vowel. Specifically, this could result in changes in voiced-unvoiced distinctions.

Design: Nineteen listeners with sensorineural hearing loss participated. A double-blind within-subject design was used to compare stop consonant categorization measured through the categorical perception task with four processing delay times (0, 0.5, 5, and 8 ms). Male spoken vowel /e/ in stop-consonant /d/ and /t/ contexts was used as stimuli. A continuum of 13 stimulus tokens was created by reducing the voice onset time (VOT) in the onset from unvoiced token ("tee") to the voiced token ("dee") in equally spaced intervals. The speech stimuli were manipulated using a hearing aid simulator that simulated both acoustic and digital paths. Data measured at discrete VOT intervals were transformed to continuous logistic functions. The psychometric functions were used to estimate the category boundary crossover point. The significance of processing delay time on perceived crossover points and slope parameters were evaluated using a linear mixed effects model.

Results: The analyses revealed a significant fixed effect of delay time on threshold parameter estimates and slope parameter estimates. Post-hoc analyses determined that the 0 ms condition resulted in thresholds that were significantly biased towards the unvoiced ("tee") percept compared to all other delay conditions. Conversely, the longest simulated delay of 8.0 ms was significantly more biased towards the voiced ("dee") percept compared to all other delay conditions. The 8.0 ms delay condition also resulted in psychometric performance slopes that were significantly shallower than those measured in either the 0 or 0.5 ms delay time conditions.

Conclusions: The current study demonstrated that hearing aid processing delay in open-fit hearing aids can impact voicing perception of syllable initial stop-consonants by shifting the percept from unvoiced towards voiced as the processing delay time increases. Results also suggest that listeners were more uncertain regarding the categorization of the studied phonemes, at and around intervals near their cross-over points, when simulated delay time was longer. If the goal is to preserve the natural VOT cues used for voicing detection, a short hearing aid processing delay times should be considered in open fittings.

Category: Hearing Technology / Amplification

Poster #: 097

Speech-in-Noise Performance with Adaptive Region Beam in a Multi-Talker Task

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Objectives: Modern hearing aids use beamforming to support highly directional microphone systems that can help wearers to follow speech in challenging acoustic environments. One drawback to such systems is that spatial enhancement is restricted to regions directly in front of the wearer. Hence, wearers may miss speech from other talkers who are located to the side of such narrow beams. A novel directional algorithm (adaptive region beam, ARB) focuses on target signals originating from multiple frontal azimuths. Theoretically, such algorithm should provide speech-in-noise enhancement for speech originating from in front of the listener, akin to traditional beamforming, as well as for speech originating from a second location to the side of the listener. The current study evaluated the efficacy of this algorithm in a noisy two target talker listening situation.

Design: The study followed a single-blind, within-subjects design. 18 older adult listeners with sensorineural loss were tested using the ARB algorithm and non-ARB based directional microphone. Listeners' speech-in-noise performance was tested using speech materials from the repeat-and-recall test (RRT) in a loud (SPL = 75 dB) cafeteria noise. Presentation of 60 target sentences alternated between two loudspeakers positioned at 0° and 35° in the azimuth. After every 20 sentences, participants were also asked to provide ratings of listening effort (10-point scale) and estimates of tolerable time (0-120 minutes).

Results: Four linear mixed effects (LME) models were used to assess the fixed effect of hearing aid microphone conditions on sentence scores, word scores, listening effort ratings, and tolerable time estimates. The LME model analyses revealed that microphone condition had a significant effect on sentence scores, word scores, and tolerable time estimates. The effect of microphone conditions on effort ratings trended in the same direction but was non-significant. Post-hoc comparisons conducted on the estimated marginal means confirmed that listeners performed better at the sentence and word level in ARB condition compared to the non-ARB condition. Similarly, listeners estimated that they would be willing to stay and tolerate communication for longer durations while listening with ARB compared to the non-ARB condition.

Conclusions: The use of ARB algorithm improved speech in noise performance over non-ARB based directional system in the presence of two spatially separated target talkers. The improved ability to focus on more than one target could help in noisy multi-talker group conversations which includes natural interactions of a conversation, effects of moving your head, and people coming in and out of the discussion.

Category: Hearing Technology / Amplification

Poster #: 098

Spectral Contributions and Covariances for Older Adults' Preferred Amplification Profiles

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Objectives: User's preferences on the amount of amplification as a function of frequency, i.e. the preferred amplification profile, have been leveraged in previous studies as a rationale for hearing-aid fitting and fine-tuning. The current study aims to investigate (1) whether listeners treat various frequency regions as equally important while making preference-based judgements, and (2) whether there are systemic covariances among the preferred gains across frequency bands.

Design: In two separate experiments, we enrolled a total of 20 older-adult participants with mild-to-moderate hearing loss, with 10 participants in each experiment. The participants' preferred amplification profiles were assessed through a 30-trial adjustment procedure. During these trials, participants used a two-dimensional control surface to make gain adjustments while listening to continuous speech presented in background noise. The map linking the coordinates of the control surface to the gains in the six octave-frequency bands, ranging from 250 to 8000 Hz, was randomly determined for each trial. The two experiments primarily differed in how the control-to-gain map was formulated mathematically, with additional differences in the design of the user interface. The target continuous speech was presented at 60 dB(A), while a simultaneous multi-talker background noise was presented at a signal-to-noise ratio of 5 dB.

Results: A covariance analysis was conducted on the participants' preferred gains across the six frequency bands. In both experiments, the participants' preferred gains in the 1- and 2-kHz frequency bands consistently exhibited the least variance. In contrast, the preferred gain in the 8-kHz band consistently exhibited the greatest variance. This indicates that the participants weighed the 1- and 2-kHz bands as more important in making preference-based judgements. Additionally, robust correlations were observed between the preferred gains in the 250- and 500-Hz bands, as well as between the 4- and 8-kHz bands.

Conclusions: The spectral weights for making preference-based adjustments were distinct from those reported previously for performing a sentence recognition task. The preferred gains in the lowest (250 Hz) and highest (8000 Hz) bands were not only most variable, they also strongly covaried with the adjacent bands.

Category: Hearing Technology / Amplification

Poster #: 099

Assessment of a Hearing Aid Training program for Healthcare Workers

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Objectives: The purpose of this study was to develop and evaluate an in-person hearing aid training program for healthcare workers and personal care aides (PCAs).

Design: Participants were 18 English-speaking healthcare workers and PCAs who were employed in nursing homes, assisted living facilities, or in private homes. All participants passed a hearing screening and vision screening. This was a randomized controlled study. Half of the participants were assigned to

the experimental group and the other half to the control group. The experimental group was administered a hearing aid training program that was developed for this study. It was specifically designed for healthcare workers and PCAs. The hearing aid training program included how to clean, insert, remove, and charge a hearing aid. Participants in the control group were trained on a table-top building maze game that was similar in complexity and time to the hearing aid training program. Both groups were administered the Practical Hearing Aid Skills Test-Revised Version 2 (PHAST-Rv2) pre- and post-training. The PHAST-Rv2 assesses performance on basic hearing aids skills and was scored by an audiologist who was blind to the participants' study group. Participants were surveyed on their experience with hearing aids and attitudes towards OTCs. At the end of the study, participants in the control group were offered the hearing aid training.

Results: Pre-training PHAST-R scores were 59.50% (SD 15.49) and 57.66% (SD 11.08) for the experimental and control group, respectively. There were no statistically significant differences between the experimental and control groups' pre-training PHAST-R scores ($t=-0.291$ with 16 df, $p=0.78$). Mean post-training PHAST-R scores were 95.84% (SD 6.32) for the experimental group and 59.96% (SD 7.59) for the control group. The experimental groups' post-training scores were significantly higher than the control groups' scores ($t = -10.91$ with 16 df, $p<0.001$). Within group differences between pre- and post-training PHAST-R scores was significantly higher for the experimental group ($t = -5.66$ with 16 df, $p<0.001$). Thus, the experimental group significantly improved how well they performed the hearing aid tasks after training and no change was observed for the control group. When participants were asked if OTC hearing aids are good for older adults, 50% (n=9) reported they were unsure, 17% (n=3) said they were not good, and 33% (n=6) thought they were good. Seventy two percent (n=13) of participants reported that they would know what to do if their client's hearing aid was whistling; eight of them reported a correct strategy (e.g., turn down the volume, clean the aid) and five reported an incorrect strategy (i.e., check the hearing aid for a dead battery).

Conclusions: A hearing aid training program developed for healthcare workers was shown to be an efficient and effective way to improve how well hearing healthcare workers can care for and operate a hearing aid. Healthcare workers vary in their opinion on the use of OTC hearing aids for older adults.

Category: Hearing Technology / Amplification

Poster #: 100

Characteristics of Older Adults Interested in Becoming First-Time Hearing-Aid Purchasers

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Objectives: Older adults who had previously never worn hearing aids were recruited for participation in a randomized controlled trial (RCT) that required them to purchase hearing aids. The audiologic and demographic characteristics of those completing an initial online screening and a follow-up in-person screening for this RCT will be presented.

Design: Persons interested in trying hearing aids were recruited for participation in an RCT that required them to become first-time purchasers of hearing aids. Adults were recruited from the general population using a wide variety of methods in two different states (Illinois and Texas) and in both urban and suburban areas. After completing a brief online screening, those who passed were scheduled for a more detailed in-person screening at one of four clinical test sites. Eligible participants were required to be between 50 and 79 years of age, to have perceived hearing difficulties, and to be new hearing-aid users. For this presentation, we focus on the results from the online and in-person screening to learn more about the characteristics of older adults with interests in hearing aids but who have not obtained them previously.

Results: A total of 1129 persons completed the online screening. This screen consisted of an adaptive version of the Revised Hearing Handicap Inventory for the Elderly-Screening version (RHHI-S) in addition to questions regarding age, previous hearing aid use, English proficiency, ability to pay $650 for the pair of hearing aids, and prior professional diagnosis of a memory or cognitive impairment. Of these, 15% did not meet the screening criteria, about half of whom had RHHI-S scores that reflected little or no perceived hearing difficulty and the remainder failing other screening questions. Of the remaining 963, 215 persons declined to participate or could not be scheduled and the other 748 were screened in-person. After confirmation of their responses to the questions asked during the online screening, the in-person screen included the following tests: (1) full 25-item Hearing Handicap Inventory for the Elderly (HHIE); (2) Montreal Cognitive Assessment (MoCA); (3) air-conduction pure-tone thresholds from 250 through 8000 Hz. For the 748 participants who returned for the in-person screen, ages ranged from 50 to 79 years with a median age of 70 years, 55.6% identified as female, 94.3% identified as White or Caucasian, and 3.6% identified as Latino or Hispanic. HHIE scores obtained at the in-person screening ranged from 0 to 100 with a median score of 36. Audiometric results showed that on average, participants had mild-to-moderate sloping audiograms. However, 11% of participants had better-ear pure-tone averages for 500, 1000, 2000 and 4000 Hz (PTA4) less than 20 dB HL, defined as "normal hearing" by the World Health Organization. The full set of online-screening data will be reviewed to form the basis of a profile for older adults interested in pursuing hearing aids.

Conclusions: Results from the front-end screenings for this RCT provide insights into the demographic and audiologic characteristics of older hearing-aid prospects.

PEDIATRIC AUDIOLOGY / OTOLOGY

Category: Pediatric Audiology / Otology

Poster #: 101

Effortful Control and Spoken Language in DHH Children: Caregiver Contributions

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Objectives: The current project examined how caregiver linguistic input and parenting stress influence the relation between effortful control and expressive language in deaf and hard-of-hearing (DHH) children. We hypothesized that in environments where caregivers provide limited language-learning

opportunities (i.e., low caregiver linguistic input, high parenting stress), only DHH children with optimal effortful control skills will achieve better expressive language. In more supportive language-learning environments (i.e., high caregiver linguistic input, low parenting stress), we predict all DHH children, regardless of their effortful control skills, will have better expressive language.

Design: Fifty-nine DHH children (mean age=5.8 years; 34 cochlear implant users, 25 hearing aid users) and their primary caregiver (54 mothers, 3 fathers, 2 grandmothers) were included from a larger study on family environment if they had completed the same age-based versions of questionnaires outlined below. All families had spoken language as a goal for their child. Data were collected during a 2-hour home visit. Caregivers completed questionnaires that measured child effortful control (Child Behavior Questionnaire - Short Form) and parenting stress (Parenting Stress Index - Short Form). Child expressive language and caregiver linguistic input were derived from a semi-structured parent-child play interaction where mean length of utterance (MLU) in morphemes and total number of different words were combined into a composite score for child expressive language and for caregiver linguistic input.

Results: Children with higher effortful control had caregivers with less parenting stress, $r(56)=-.470$, $p<.001$, and greater MLUs, $r(56)=.316$, $p=.016$. While not significant, there was also a trend for caregivers reporting greater parenting stress to have shorter MLUs, $r(56)=-.158$, $p=.083$. Whereas child effortful control was not correlated with any of the child expressive language measures, the model predicting child expressive language from child effortful control and caregiver linguistic input was significant, $F(5,54)=6.75$, $R^2=.33$, $p<.001$, and showed significant moderation, $F(1,54)=5.05$, $p=.029$, $\Delta R^2=.06$. When caregivers provided lower-level linguistic input ($b=0.549$; $p=.049$), but not moderate ($b=0.113$; $p=.495$) or high ($b=-0.360$; $p=.151$) levels, children with better effortful control had better expressive language. Finally, the model that predicted child expressive language from child effortful control and parenting stress approached significance, $F(5, 54)=2.43$, $R^2=.15$, $p=.058$, although there was a significant interaction between effortful control and parenting stress, $F(1,54)=5.17$, $p=.027$, $\Delta R^2=.08$. When parenting stress was low ($b =0.814$; $p=.009$), but not moderate ($b=0.383$; $p=.069$) or high ($b=-0.058$; $p=.821$), high child effortful control was related to better child expressive language.

Conclusions: The results suggest a potential link between parenting stress and caregiver linguistic input that could contribute to spoken language skills in DHH children. More complex caregiver utterances appear to provide an expressive language benefit for DHH children regardless of their regulatory abilities while lower levels of parenting stress enable DHH children to leverage their regulatory skills. Further, these preliminary results suggest that parenting stress might create an environment that interferes with DHH children's ability to leverage their regulatory abilities to achieve better expressive language skills. These results highlight the important influence caregivers have to foster a home environment that can support spoken language outcomes and compensate for their DHH child's inherent regulatory capacities.

Category: Pediatric Audiology / Otology

Poster #: 102

Intra-Conversational SNRs at Intervention Groups for Children with Hearing Loss

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Objectives: The first years of life are crucial for language learning and therefore it is essential that children have adequate access to speech during this period. For children with hearing loss the access to linguistic input is deteriorated, and cannot always be fully compensated by hearing aids. As a result, children with hearing loss are at risk for language difficulties. In order to optimize access to language for children with hearing loss, the acoustic environment is of great importance. Listening in suboptimal acoustic environments is harder for children compared to adults, and even harder for children with hearing loss compared to normal-hearing peers. Optimal acoustics are characterized by high SNRs, low background noise levels, and low reverberation times. In this study we explore the acoustic characteristics of an environment important for language acquisition; intervention groups for children with hearing loss from the age of 18 through 48 months. These groups are guided by professionals with knowledge of hearing loss, hearing aids and language acquisition, and are therefore considered to be an optimal environment for children with hearing loss. The obtained characteristics will help with evaluation and advice on acoustic properties for comparable settings in which young children with hearing loss reside, like daycare centers.

Design: All children with hearing loss visiting one of seven participating groups were approached. This led to a total inclusion of 26 children. All children wore a Language ENvironment Analysis (LENA) device during one group visit to investigate characteristics in the occupied setting, as experienced by the children. LENA Advanced Data Extractor (ADEX) was used to identify the sound sources and the corresponding sound levels in dBC in the recordings. LENA ADEX distributed all sound sources in conversation blocks and pause blocks. The speech and noise levels within conversation blocks were used to determine intra-conversational SNRs. To investigate unoccupied characteristics, background noise and reverberation time were measured.

Results: The median speech level of the professionals over all recordings was 72.1dBC, the median noise level was 62.0dBC. When correcting for the conversation block duration, which varies between 0.6 and 251 seconds, the median SNR over all locations was +12.8dB (9.9 - 16.2 over different locations). Reverberation time was between 0.3 and 0.6s for all groups, which complies to the ANSI standard for classrooms with children without hearing loss, while only one group complied to the norm of 0.3s for children with hearing loss. Background noise levels were between 28.9 and 38.6dBA, complying with ANSI norms for six out of seven groups.

Conclusions: The acoustic environments of young children with hearing loss visiting early intervention groups were evaluated. The intra-conversational SNR of adult speech was above the ASHA recommended SNR of +15dB in classrooms in only 42% of the times. On the other hand, acoustic recommendations are developed for school aged children and are not verified in settings for younger children. SNRs above +15dB may not be feasible for young children, often playing throughout the room and also outside. Current results provide an overview of potentially optimal acoustic environments of young children.

Category: Pediatric Audiology / Otology

Poster #: 103

Examining Language Use in Spanish-Speaking Children Who are Hard of Hearing

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Objectives: Spanish-speaking families who have children who are hard of hearing (CHH) report feeling pressure to focus on English language development in the US. Healthcare professionals like audiologists and speech-language pathologists can provide counseling to Spanish-speaking families on effective dual-language learning strategies. One key part of this counseling is to help families create a language plan to meet their language goals for their child. This project examines a) Spanish-speaking families' language plans and how effective caregivers perceive the outcomes to be, and b) hearing aid (HA) use across language(s) for CHH. This is crucially important to assess because in bilingual CHH auditory dosage and language exposure vary across both languages and patterns likely impact outcomes.

Design: This feasibility study has three phases. In Phase 1, a comprehensive audiological profile is created per CHH by analyzing audibility, HA verification measurements (i.e., Speech Intelligibility Index), and hearing health history data via questionnaire. A comprehensive bilingual language profile is created by analyzing language data collected via questionnaire, and Spanish and English receptive vocabulary size via standardized testing. In Phase 2, caregivers complete daily ecological momentary assessment (EMA) surveys at regular intervals, up to seven times a day, over the course of one week. In these surveys caregivers report when their child is wearing their HAs, what language(s) they are hearing and speaking, and what activity they are doing. Caregivers can elect to complete the surveys in either Spanish or English. In Phase 3, caregivers are interviewed using a semi-structured protocol that assesses the constructs of hearing health background, hearing aid use, language use, and barriers to audiological care and counseling. Sixteen questions across the constructs were formulated by a research team including an audiologist, speech-language pathologist, and evaluation expert. Interviewers were formally trained to ensure reliability in the parameters for asking relevant follow up questions, maintaining appropriate empathy, and maintaining control. Interviewers maintained a role of researcher throughout interviews but empathized with parents as healthcare professionals. Semi-structured interview questions were piloted and iterated prior to implementation in present analysis. Participants select their preferred language for the interview. Coding is completed by reading through interview transcriptions and forming initial codes. Themes are formed by aggregating codes by construct.

Results: Recruitment is ongoing for this feasibility study. Consistency of caregiver report of language use between retrospective surveys and EMA surveys are assessed. Patterns in HA use by language (Spanish and English) are explored. Summaries of themes regarding language planning and language outcomes from semi-structured interviews are discussed.

Conclusions: Capturing daily language use in Spanish-speaking families who have CHH is critical to build a strong evidence base for effective counseling strategies to support dual-language outcomes.

Category: Pediatric Audiology / Otology

Poster #: 104 **Mentored Student Research Poster Award**

Effects of Ear-Tip Loosening on Wideband Absorbance Measurements in Newborns

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Objectives: Power absorbance, a wideband acoustic immittance (WAI) measure, is sensitive to outer and middle-ear sound-conduction dysfunction. Acoustic leaks due to loose probe fits in the ear canal, a common issue in newborns, artificially increase absorbance at low frequencies (low-f). Microscopic holes introduced in the probe tips reportedly resulted in leak-related changes (ΔAbsorbance) which were predictable by low-f absorbance and impedance phase (∠Z) in adults. Those predictive relationships were identical with a simple progressive probe loosening procedure. The purpose of this work is to investigate the effect of probe loosening in newborns with normal and abnormal sound conduction. Objectives were to (1) assess whether low-f absorbance and ∠Z predict ΔAbsorbance in newborn ears that pass and fail TEOAE screening, and (2) compare those relationships to previously reported effects of probe loosening in normal-hearing adults.

Design: 237 newborns (<48 hours of age) underwent repeated sequence of WAI, TEOAE measurements, and ear-canal pressurization sweeps (0 to -400 daPa). To simulate different degrees of acoustic leaks, WAI measurements with progressive probe loosening were conducted. ΔAbsorbance values were calculated as the differences between the 'no-leak' measurement, with maximum pressurization (-400 daPa), and each successive measurement. Correlation and best-fit analyses evaluated the relationships between ΔAbsorbance and each low-f absorbance and ∠Z. These correlations were performed for TEOAE-pass (n=195 ears) and TEOAE-fail (n=66 ears) separately, and their outcomes were compared. Additionally, the same set of correlations were performed in 23 normal-hearing adults to compare with the newborn group.

Results: In newborns, probe loosening resulted in strong positive linear correlations between ΔAbsorbance and low-f absorbance for TEOAE-pass, and a moderate correlation for TEOAE-fail data. The trendlines from the two correlations were parallel, though a 0.1-shift along low-f absorbance was observed, greater for TEOAE-pass than TEOAE-fail data. Compared to normal-hearing adults, similar linear relationships were observed, albeit with a 0.18-shift along low-f absorbance, greater for TEOAE-pass compared to adult data. Additionally, the relationships between ΔAbsorbance and low-f ∠Z were quadratic in nature, with a proportional increase over lower ∠Z values, followed by a rollover in ΔAbsorbance as ∠Z increased. In newborns, trendlines for TEOAE-pass and TEOA-fail data were similar with negligible shifts, and exhibited moderate and strong relationships, respectively. In comparison to normal-hearing adults, the relationships were similar, except for an

earlier rollover point in the TEOAE-pass newborn group, around 0.02 cycles, compared to 0.1 cycles in the adult group.

Conclusions: Low-f absorbance and ∠Z predict ΔAbsorbance in newborn ears similarly for TEOAE-pass and TEOAE-fail ears, with a minor systematic shift in low-f absorbance noted for TEOAE-fail data, attributed to reduced absorbance in the presence of conductive dysfunction. Therefore, it is possible to predict loose probe fits using low-f absorbance and ∠Z, irrespective of the status of sound conduction, with a correction factor on the former. Moreover, similarities in overall findings in adults and newborns were observed with some differences, attributed to maturational factors, e.g., greater low-f absorbance in newborns due to ear canal wall resonance, and greater low-f ∠Z due lower-frequency resonance in newborns compared to adults.

Category: Pediatric Audiology / Otology

Poster #: 105

Slight-Mild Hearing Loss in Prematurity Related to Language Outcomes

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Objectives: The overall aim of this report is to examine hearing loss detected by newborn screening and diagnostic testing at 2-3 years in relation to spoken language outcome. Additional covariates (medical, birth, demographic, sensory, cognitive and motor development) were included in models to predict language outcome.

Design: The study cohort was enrolled in a longitudinal, population-based cohort study of very and extremely premature infants recruited soon after birth from five Cincinnati NICUs, known as the Cincinnati Early Prediction Study (CINEPS). From the CINEPS cohort of infants born at ≤32 weeks gestational age (395 children), we enrolled a subset of children at 24-36 months old (n=124). Infants with known chromosomal or congenital conditions affecting the central nervous system or who were medically unstable at term-equivalent age. Due to the language outcome measures, families who did not primarily speak English were excluded. Perinatal clinical variables known or suspected to be associated with brain injury, abnormal development, or cognitive deficits and extensive data about the mother and infant were collected, along with conditions known to be associated with hearing loss, such as cleft palate or Down syndrome. Global Brain Abnormality Score (GBAS) was assessed from the MRI scans. This measure is a composite of four regional MRI measurements including cortical gray matter, total white matter, deep nuclear gray matter, and cerebellar scores. 24 months corrected gestational age (CGA) - the Bayley-III Scales of Infant Development was completed. At 3 years, corrected for gestational age at birth (CA), the Test of Early Language Development-4 was performed by speech-language pathologists. Hearing was screened at birth and tested diagnostically by audiologists at 2 and 3 years CA.

Results: Multiple factors emerged that were associated with poorer language outcomes: Hearing level, maternal education, child's race, cognition, and male sex. We found a higher prevalence of sensorineural hearing loss than reported previously (6% compared to 1-4%), likely due to more sensitive criteria to detect slight-mild hearing loss. Newborn hearing screening was not as sensitive to slight-mild hearing loss compared to diagnostic testing. Only 1 out of 8 children identified in this study with SNHL had failed newborn hearing screening. SNHL, which is a permanent form of hearing loss, was associated with poorer spoken language, Conductive hearing loss is usually temporary, and was not significantly associated with lower spoken language scores. Examining individual children who performed below average (Std Score<90) on language, 87% had hearing loss, low maternal education, or were non-white. Of the children performing above average (Std Score > 110) on language, only 17% had hearing loss, low parent education, or were non-white.

Conclusions: Hearing loss is a factor that can be tested more sensitively at birth using physiologic methods. In combination with demographic factors (mother's education and child's race), these factors can identify children for earlier language enrichment methods that help parents to promote their child's language skill development.

Category: Pediatric Audiology / Otology

Poster #: 106

Sound Level Exposures for Preterm Infants in the NICU

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Objectives: When an infant is born preterm, they transition prematurely from the mother's womb to the neonatal intensive care unit (NICU), which is an entirely different physical and acoustic environment. To better understand and characterize the NICU auditory experience, we sought to examine the sound pressure level (SPL) exposures for infants in the NICU and factors that may influence those levels, including bed type (incubator vs open crib), room type, time of day, type of oxygen delivery device used, and postmenstrual age (PMA).

Design: Data were collected for very preterm infants (born ≤ 32 weeks' gestation; n = 36). Audio recordings were collected over 24-hour intervals, three times per week throughout NICU stay for each subject using a LENA recorder that was adhered to the inside wall of the infant's incubator or crib. Average hourly and daily SPL estimates were calculated from the raw recordings. We analyzed SPLs for 15,000+ hours of auditory exposures, with hundreds of hours for each subject. Additionally, electronic medical record (EMR) data for each infant were documented on an hourly basis by the NICU nurses.

Results: Preliminary analysis indicates that sound level exposures are higher in incubators (61.7 dB SPL) compared to cribs (60.72 dB SPL). Hourly sound levels exhibit oscillations every three hours, aligning with caregiving times. Staff shift changes in the NICU occur at 07:00 and 19:00, and this time frame was

used to set the day/night shift timeframe. Daytime shift SPL averages 61.5 dB, while nighttime exhibits a reduction of 0.93 dB. Analyses are ongoing.

Conclusions: Several factors may influence auditory exposures in the NICU. While the observed differences in bed type and time of day may be statistically significant, their clinical implications remain unclear. For example, whether and how a 1-dB increase in daily sound level exposure over the course of weeks and months of NICU stay might influence auditory nervous system development at this stage of life is unknown. The dynamic nature of the acoustic environment in the NICU is underscored by hourly variations and patterns of care times and shift changes. Further analyses will examine whether SPLs in the NICU are affected by room, O2 devices, and PMA. 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.[Supported by NIH R21-DC017820]

Category: Pediatric Audiology / Otology

Poster #: 107 **Mentored Student Research Poster Award**

Self-Generated Noise and Ear Canal Acoustics Impact Preschoolers' Audiometric Thresholds

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Objectives: The Finding Appropriate Solutions to Treat Reduced Audibility in Kids (FASTRAK) study is a multi-center study designed to develop and validate clinical tools to improve diagnostic assessment and outcomes of children with mild hearing loss. The current study is an adaptation of FASTRAK using conditioned play audiometry (CPA) to assess the influence of self-generated noise and ear canal acoustics on threshold estimation in preschoolers. For children of the same age, differences in ear canal sound pressure levels can range from 10-15 dB SPL. Additionally, self-generated noise is audible to children with normal hearing or mild hearing loss and can mask their audiometric thresholds. Accounting for ear canal acoustics and self-generated noise may improve the accuracy of behavioral threshold assessments in children. The specific questions addressed by this study include: 1) How is threshold accuracy affected in preschoolers when using audiometric procedures that calibrate signal level in the ear canal? We predicted that the FASTRAK audiogram, which included ear canal calibration, would produce more accurate thresholds measurements than those obtained from clinical audiometry. 2) How much threshold variability is due to self-generated noise in 3- to 5-year-olds? We predicted that self-generated noise would affect 500 Hz thresholds the most, and children in the youngest group would produce the highest levels of noise.

Design: Examiners assessed 36 children, ages 3-5 years. Parents did not report permanent hearing loss, developmental delays, or visual impairments. All children used spoken English to communicate. Parents completed an intake form regarding the child's hearing history and demographic information. The audiometric testing protocol included otoscopy, tympanometry, distortion product otoacoustic emissions (DPOAE) screening, a FASTRAK audiogram, and a clinical audiogram. Audiometric thresholds were measured using CPA at 0.5, 1, 2, 4 kHz for each ear. The FASTRAK audiogram recorded thresholds in both dB HL and SPL and was administered via computer-based software that included monitoring of ear-canal

sound levels and ear canal acoustics. The clinical audiogram was performed with insert earphones to serve as a control for each child.

Results: A linear mixed effects model compared thresholds by condition, controlling for noise level, age, and listener sex. Significant predictors of thresholds were age and noise. Thresholds improved by 4.5 dB HL per year of age, even though noise increased by 1.7 dB per year of age. The frequency by condition interaction was significant, with the different conditions yielding different estimates of threshold by frequency. The FASTRAK dB HL and clinical audiogram dB HL thresholds were significantly different (> 5.1 dB) at 500 Hz. FASTRAK dB SPL thresholds were significantly higher than FASTRAK and clinical dB HL thresholds across all frequencies.

Conclusions: The clinical implications of this research are significant in that accounting for differences in ear canal acoustics and self-generated noise may improve the accuracy of threshold measures in children. Additionally, audiometric procedures that calibrate signal level in the ear canal provide a more accurate picture of threshold changes over time. This can support audiologists in their clinical decisions when determining if there has been a true change in hearing.

SPEECH PERCEPTION

Category: Speech Perception

Poster #: 108

Automated Speech Audiometry for Children and Adults Using Kaldi-NL Automatic Speech Recognition

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Objectives: The digits-in-noise (DIN) test is widely used in speech audiometry to assess speech perception in noise for adults and children. In the clinical setup, clinicians run the test and score the participants' spoken responses. In the online version, participants manually enter the digits they heard using a keypad. We propose a third, alternative setup where participants' spoken responses are automatically scored using automatic speech recognition (ASR).

Design: We used the adaptive DIN test with 24 digit-triplets presented in noise at varying levels, with native Dutch normal-hearing adults (Experiment 1; n=30, age range 19-64 yr) and children (Experiment 2; n=23, age range 5-17 yr). Participants' responses were automatically scored after being decoded by the Dutch instance of the ASR toolkit Kaldi, Kaldi-NL. The main advantage of Kaldi-NL is that it is an open-source pre-trained off-the-shelf system. Adults were tested with the conventional test setup via a computer. Thereafter, with children, considering their limited attention span, and aiming to overcome the waiting time for Kaldi-NL to decode each response, we used a humanoid NAO robot to conduct the test as a means to compensate for these potential challenges.

Results: Kaldi-NL performance was evaluated for how accurate it was in correctly decoding the spoken digits, through the ASR word error rate (WER, ratio between the sum of insertions, deletions and substitutions, and the total number of recorded spoken digits). For Experiment 1, the average WER was 5.0% (range 0-13.5%, SD = 3.6%), excluding an outlier whose WER was 48%. We found an average of three triplets with Kaldi-NL decoding errors per participant. Following, we evaluated how the Kaldi-NL decoding performance could affect the DIN test score, expressed in speech reception threshold (SRT). Previous research indicates 0.70 dB as typical within-subjects variability for NH adults. Using this as a criterion, bootstrapping simulations showed that up to four triplets with decoding errors produce SRT variations within this range, suggesting that our proposed setup could be feasible for clinical applications.The average WER for Experiment 2 was 18% (range 2.8-69.2%, SD = 18.5%), with an average of eight triplets with decoding errors per participant. Kaldi-NL's WER decreased as a function of age of the tested children, although the reported WER for the oldest children was not as low as that of adults.

Conclusions: We have presented a simple system for automation of the scoring of the DIN test using the widely available ASR for Dutch, Kaldi-NL. When testing native Dutch speaking adults, our bootstrapping results suggest that the proposed system could give comparable results to the currently used clinical setup. It is not yet known whether or not the proposed system can still provide reliable measures for speech audiometry for children, as there are no documented values of the intrasubject variability of the DIN test SRT for normal-hearing children to compare our results to. Further work includes the comparison of our children's DIN test SRTs to those acquired with the typical clinical setup, and exploring how the ASR performance can be improved.

Category: Speech Perception

Poster #: 109

Normative Data for AzBio Performance in Adult Bilingual Speakers

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Objectives: To establish normative performance of bilingual Spanish/English speakers on the Spanish and English AzBio Sentence Tests, and to determine if differences exist in performance based on test language. We hypothesized better performance on the Spanish AzBio Sentence Test in noise conditions and similar performance on the Spanish and English AzBio Sentence Test in quiet conditions.

Design: Participants included 14 Spanish-English bilingual speakers aged 21-49 years with normal hearing. The English and Spanish AzBio Sentence Tests was performed in quiet and using 3 signal-to-noise ratios (SNRs; 0, ± 6). Both speech stimuli and 10-talker babble noise were calibrated in the sound field at 60 dBA and were presented at 0 degrees for both languages. 2 lists were presented at each SNR condition and 1 list was presented in quiet. Language presented was counterbalanced and list numbers were randomly generated for all conditions. For each list, the number of words correctly identified per

sentence was summed and divided by the total number of words per list to generate a percentage. The possible range of scores spanned from 0-100% correct.

Results: The mean AzBio Sentence Test score was 14.62%, 69.41%, and 91.29% at -6, 0, and +6-dB SNR in Spanish and was 3.60%, 42.50%, and 86.75% at -6, 0, and +6-dB SNR in English, respectively. Mean AzBio Sentence Test scores presented in quiet achieved ceiling for Spanish (98.54%) and English (96.14%). No statistically significant differences were found between test languages; however, there is a clinically meaningful difference at the 0 dB SNR condition, with better performance in Spanish (69.41%) than English (42.5%).

Conclusions: This study aimed to address the present gap in the literature concerning norms for performance on speech perception measures used to determine candidacy for hearing intervention in Spanish-English bilingual speakers. Normal hearing, Spanish-English bilingual speakers performed better in Spanish in all noise conditions and at ceiling for quiet for both languages. Future research assessing English and Spanish AzBio Sentence Test performance in hearing impaired, Spanish-English bilingual speakers is needed to develop clinical norms.

Category: Speech Perception

Poster #: 110

Music Training, Cognition and Speech Perception in Noise in Children

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Objectives: Research shows a speech-perception-in-noise (SPIN) advantage in musician children, but conflicting results in adults underscore the need for a comprehensive examination. Additionally, some studies have suggested that general intelligence might explain the SPIN advantage in adult musicians, while others underscore the critical contribution of working memory skills. Thus, this study aims to 1) replicate previous findings showing that music training predicts SPIN skills in children, and 2) investigate whether the musician SPIN-advantage is influenced by cognitive factors, including general intelligence, and working memory. We hypothesized that in children, more years of music training would be positively associated with SPIN skills even when controlling for IQ differences. However, we also hypothesize that the variance on SPIN skills explained by years of instrument training will be significantly reduced when controlling for working memory differences.

Design: This study is ongoing. To date, we have recruited 28 children aged 10.0 to 12.9 years (M = 11.6, SD = 1.1) with normal hearing and typical development. These children have varying degrees of music training ranging from 0 to >5 years (M = 2.0, SD = 2.7). As part of the study, children complete the Kaufmann Brief Intelligence Test to measure general intelligence, the Bamford-Kowal-Bench Speech-in-Noise test to measure speech perception skills, and the Auditory Working Memory Index subtest from the Weschler Intelligence Scale for Children to assess auditory working memory. In addition, families complete a detailed demographic questionnaire, including a music training section. We use years of music training as a continuous variable to compute hierarchical multiple regression analyses. This study

has been registered in a journal of our field. Power analyses revealed that 62 participants are sufficient to detect expected effect. Thus, we plan on collecting data on the proposed sample soon.

Results: Preliminary analyses confirmed our hypotheses. Children with more years of music training showed better SPIN skills than those with no or fewer years of music training (r = .35). In addition, the positive association between years of music training and SPIN skills is explained by working memory skills but not general intelligence.

Conclusions: The study confirms a positive relationship between music training and SPIN skills. Importantly, it reveals that this relationship is associated with auditory working memory skills, rather than general intelligence. These findings suggest that music training may serve as a beneficial factor for enhancing SPIN skills in children, with implications for potential interventions with clinical populations known to struggle listening in noise (e.g., children with hearing loss). The understanding that working memory plays a pivotal role underscores the importance of considering other interventions targeting auditory working memory to facilitate SPIN in clinical populations of children. Overall, the study provides valuable insights into the nuanced interplay of music training and cognitive factors in shaping SPIN skills in the pediatric population.

Category: Speech Perception

Poster #: 111

Gender and Speech Material Effects on the Full-Band Speech LTASS

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Objectives: Gender and language are reported to influence the long-term average speech spectrum (LTASS). Extended high frequencies (EHFs; > 8 kHz) play a role in speech recognition in noise, speech perception, and sound localization. The audibility of EHF cues depends on their spectral levels, but it is unclear to what extent these levels are influenced by gender and speech material. In this study, we aimed to investigate the effect of gender and speech material on the LTASS, including at EHFs.

Design: A corpus of high-fidelity, anechoic, multi-directional speech recordings was created. Recordings of 30 native speakers of American-English (15 males, 15 females) were used to examine the LTASS at 0 degrees. Speech materials recorded for each subject included a subset of the Bamford-Kowal-Bench sentences (BKBs), digits 0-10, and an unscripted narrative. Recordings were normalized to have an overall level of 65 dB SPL and then equivalent rectangular bandwidth (ERB) scaled LTASS levels were calculated. Effects of gender and speech material were tested using linear mixed-effects models with subject as a random factor.

Results: Analyses revealed a main effect of gender on spectral levels. Females had higher levels than males by approximately 4 dB at EHFs and 2-6 dB at ERBs with center frequencies of 313, 806, and 924 Hz. Male levels were higher than females at ERBs with center frequencies ≤ 123 Hz. The LTASS showed a small (~2 dB) but significant increase in EHF levels for narratives compared to BKBs; however, there was no difference in EHF level between BKBs and digits. The gender differences at EHFs reduced with increasing frequency and also had a significant interaction with speech material. Comparison of mean EHF levels with previous studies revealed some differences, possibly attributable to individual variability in the LTASS, which was substantial.

Conclusions: Our findings suggest that LTASS levels at EHFs are influenced by gender and the phonetic content of speech and highlight the possibility that EHF cues are more audible for female speech than male speech. EHF levels differ markedly across talkers within a gender, differing by up to 15 dB. Gender differences observed in this study may be related to anatomical differences in vocal tract length and size, and differences in fundamental frequency. Effects of speech material are potentially related to representation of voiceless fricatives that tend to have spectral peaks at higher frequencies. Differences observed across studies could be due to factors including (1) differences in speech materials used, (2) recording setup and quality of recordings, and (3) high variability of EHF levels across talkers. These results have implications for hearing aid gain prescription, as well as for speech perception research and clinical assessments of hearing.

Category: Speech Perception

Poster #: 112 **T35 Research Trainee Poster**

Effects of Imperfect Captions on Listening-Related Fatigue

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Objectives: Struggling to hear and understand in challenging listening environments can be fatiguing for many individuals with hearing loss (HL). Some research suggests that the use of hearing aids or cochlear implants may reduce this "listening-related fatigue". While research examining alternative interventions is scant, live captioning may prove useful in some situations. Captioning has been shown to improve speech understanding and reduce perceived listening effort in some listening conditions. In this pilot study, we examined the effects of captioning on listening-related fatigue in normal-hearing listeners using subjective and objective measures. We hypothesized that access to captions would reduce both subjectively and objectively measured fatigue.

Design: Participants included twenty-two adults (18-69 years old) with essentially normal hearing. To induce listening-related fatigue, participants completed a sustained (~50 minute) dual-task. The primary task was audiovisual speech recognition in quiet. Speech levels were individually adjusted to achieve ~70% correct in the no caption condition. The secondary task was reaction time (RT) to auditory keywords presented during the speech task. Participants were randomly assigned to complete the dual-task with or without captions. Subjective fatigue was assessed via a rating scale presented before, during, and after the dual-task. Objective fatigue was defined as a decrement in vigilant attention over time and

was measured via: 1) changes in keyword RTs over the course of the dual-task or 2) changes in visual RTs before and after the dual-task, measured using the Psychomotor Vigilance Task (PVT).

Results: As expected, audiovisual speech recognition was significantly better for the caption compared to the no caption group ($p < 0.01$). Subjective ratings of fatigue increased significantly over the course of the dual task. Contrary to our initial hypotheses, however, subjective fatigue ratings were higher for the caption, rather than the no caption group ($p < 0.05$) . Keyword RTs were also significantly longer in the caption group ($p < 0.001$), although RTs did not increase significantly over time. Taken together the results suggest the task induced some fatigue and providing access to imperfect captions improved speech intelligibility, but actually increased fatigue.

Conclusions: Although access to captioning improved speech understanding, it also appeared to make the listening task more fatiguing. Subjective ratings of fatigue were significantly higher in the caption group. Objective measures (i.e., PVT RTs) also suggested significantly greater fatigue in the caption group. Reasons for these findings are unclear. However, the captions used mimic live captioning (e.g., Zoom or live television) in that they were delayed from the onset of the audio and contained deletion errors (1-2 words/sentence). Increased subjective fatigue and participants' anecdotal reports suggest that attempting to combine imperfect textual and audiovisual information was challenging for participants. It is unclear whether these challenges exist under other conditions (e.g. auditory-only) or for listeners with HL. Further research is needed to investigate the mechanisms responsible for the increased fatigue observed with captions in our study. Such knowledge may allow leveraging of the speech-understanding benefits of captioning to, under certain conditions, reduce listening-related fatigue for hearing-impaired listeners.

Category: Speech Perception

Poster #: 113

Firefighter's Speech Recognition: Effects of Noise, Experience, and Two-Way Radios

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Objectives: Clear communication is crucial for firefighters' success and safety, yet high levels of noise, hearing loss, and personal protective equipment create challenges to understanding speech. Two-way radios are the primary mode of communication, and despite signal processing advancements, they yield degraded speech in noisy firefighting conditions. The current study investigates the performance of these radios in dynamic noise conditions and evaluates their interaction with factors influencing communication, such as hearing loss and cognition. Objectives include characterizing radio effects on speech and measuring speech-in-noise recognition in relation to noise levels, hearing thresholds, and firefighting experience. This research seeks to deepen our understanding of how listening experience impacts speech-in-noise recognition and to develop strategies for improving communication among firefighters. We hypothesize that firefighting experience can compensate for increased noise and hearing loss, improving speech recognition compared to non-firefighters. The study will also explore the cognitive cost of these compensatory strategies.

Design: Prior to speech testing, the acoustic performance of the Motorola APX 7000xe radio, provided by the local fire institute, was characterized in MATLAB using pink noise. Speech recognition testing used the Quick-SIN with two listener groups (n=20 firefighters; n=20 non-firefighters). Target sentences, recorded using head and torso simulators (KEMAR), were presented with and without two-way radios - in quiet or fire noise at fixed SNRs (-9 and -15 dB), yielding four test conditions. Realistic fire noise was simulated using auditory steering, applying a circular shift to a 30-sec fire segment to generate 10 variations, enhancing authenticity. Listeners, tested over headphones, repeated back sentences, and scoring was based on correct keywords, considering group and condition. Hearing was assessed using pure-tone audiometry and hearing history surveys.

Results: The radio system exhibits a bandpass filter effect, attenuating lower (<1700 Hz) and higher (>3200 Hz) frequencies while amplifying the critical 1700-3200 Hz range to prioritize speech. Preliminary findings from the control group indicate a significant drop in speech intelligibility when recognizing sentences over two-way radios, even in quiet settings. The control group recognized significantly fewer sentences of radio speech relative to non-radio speech in quiet. Noise further reduced performance, with 59% correct at -9 dB SNR and 40% correct at -15 dB SNR. Data collection from firefighters aims to compare results and explore how hearing thresholds and firefighting experience impact performance.

Conclusions: In summary, the radio system's bandpass filter, emphasizing the 1700-3200 Hz range crucial for speech, reflects its prioritization of speech intelligibility. However, preliminary results from the control group underscore a substantial decline in speech intelligibility when using two-way radios, even in quiet environments. Overall, speech recognition in quiet was poorer when transmitted through the radio compared to when not through the radio. The introduction of noise further exacerbated the decline. Despite the implementation of signal processing algorithms to enhance radio communication, findings from the control group demonstrated that two-way radios pose a significant challenge to speech intelligibility, even in quiet. The ongoing data collection from firefighters will provide valuable insights into how hearing thresholds and firefighting experience influence performance, guiding future communication enhancements in challenging environments.

Category: Speech Perception

Poster #: 114

Evaluating the Contribution of Speech Fine-structure at Different Signal to Noise Ratios

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Objectives: Fine structure (FS) is considered important for the perception of speech in the presence of noise. Clinical tests for FS processing utilize non-speech stimuli, however, they do not inform real-world speech perception. An open question exists if fine strucuture (FS) contributes to speech in noise perception beyond the envelope and recovered envelopes, and if we can develop tests of speech in noise perception targeting FS processing. There is a lack of a clinically viable tests for FS processing using speech stimuli that can inform about speech perception deficits, which could then be used to inform

hearing rehabilitative strategies to design better amplification strategies in hearing aids and speech coding strategies in cochlear implants. In this study we propose a novel speech-based test for assessing FS processing and how they contribute to speech perception in different signal to noise ratios, by circumventing the current confounds associated with speech-based tests for FS processing. We hypothesize that listeners leverage FS cues for speech perception in noise at difficult signal-to-noise ratios (SNR) than at favorable SNRs.

Design: In this study we evaluate parametric changes in the amount of FS information needed to improve speech perception in noise, which can in turn be interpreted as the magnitude of speech perception benefit provided by FS cues. We parametrically introduced varying amounts of FS in speech while keeping the envelope constant and trace changes in the speech perception in noise scores at +6, +2 and -2 dB SNRs. We use a within-subjects design with 2 within-subject factors (3 levels of noise and 11 FS timescales) to study the contribution of FS to speech perception across different SNRs. The stimuli for the speech-based portion of the test was presented to the participants at a suprathreshold intensity level of 70 dB HL (half-gain rule applied for SNHL participants) through a calibrated sound interface (RME Fireface UCX II) and insert earphones (ER-3A). The sentences from the different timescale conditions were presented in a random order to avoid order effects, and participants' verbal repetition of the stimuli was recorded. Live scoring and offline scoring were performed. The number of correct key words repeated per sentence per timescale was scored. A psychometric function was constructed to evaluate the relationship between FS timescale and speech perception in noise. The experiments were performed across multiple sessions to avoid fatigue. The data collection is underway and the data will statistically assessed using a repeated measures analysis of variance (rmANOVA) approach with SNR(3 levels) and timescale (11 levels) as the main effects and SNRxtimescale as the interaction effect. Prior to rmANOVA, the data was tested on Mauchly's test of sphericity. These tests will be used to determine if speech perception is significantly different across SNRs and timescales. Follow up post-hoc tests was performed with appropriate corrections for multiple comparison to assess the specific pattern of differences within each SNR across different FS timescales.

Results: The data collection is ongoing. We observed that listeners leverage FS cues maximally at +2 dB SNR and -6 dB SNR than at +6 dB SNR. The contribution of FS to speech perception shows a non-monotonic increase with temporal integration of FS.

Conclusions: Preliminary results suggest that the test can be used to reliably study speech perception in noise. Listeners appear to leverage FS cues only at low signal-to-noise ratios, and the temporal integration for FS cues plateaus after 70 ms.

Category: Speech Perception

Poster #: 115 **Mentored Student Research Poster Award**

Speech Perception in Age-Related Hearing Loss: Aided vs Unaided fNIRS Findings

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Objectives: Age-related hearing loss (ARHL) impacts approximately 50% of US adults over 75, yet 78% do not use hearing aids, despite their demonstrated benefits. ARHL has been associated with conditions such as dementia, social isolation, cognitive decline, and a diminished quality of life. The aim of this presentation is to offer a preliminary insight into behavioral and neurophysiological changes during speech perception in noise with and without hearing aids in individuals with ARHL.

Design: Twelve participants (N=12, Mean Age=80.3) with bilateral sensorineural hearing loss and a speech frequency pure tone average exceeding 40 dB HL have been enrolled in an on-going two-group, parallel, randomized, wait-list controlled trial. All participants scored 26 or higher on the Montreal Cognitive Assessment, indicating normal cognitive function, but none had worn hearing aids prior to enrollment. During baseline, participants repeated sentences in 4 conditions, with and without the use of hearing aids. All participants were fit with binaural hearing aids (Signia Pure Charge and Go (C&G) 7AX and Oticon More 1) using NAL-NL2 prescriptive formula. The sentences were taken from the Quick Speech in Noise Test and presented in quiet and at 3 SNR conditions (3, 6, and 9 dB). The Hitachi ETG-4000 system with 44 channels recorded cerebral hemodynamic responses, focusing on the frontal and temporal lobes.

Results: As expected, participants recalled more keywords in the aided condition as opposed to the unaided condition. Speech perception accuracy displayed a stepwise progression in performance, where the lowest accuracy was in the most challenging 3 dB condition and was highest in the quiet condition. Group contrasts were conducted to compare neural activity between aided and unaided conditions. In the quiet listening condition, there was greater neural activation in frontal and temporal lobes when participants were wearing hearing aids compared to when they were not. However, in both 6 dB and 9 dB SNR conditions, there was a consistent pattern of increased neural activation in the temporal lobe and decreased activation in the frontal lobe when participants were wearing hearing aids.

Conclusions: Preliminary data suggest that hearing aids enhance cortical activity in brain regions associated with processing, storing, and recalling speech, thereby improving performance in quiet conditions by reducing the need for participants to suppress competing noise. However, in noisy settings, despite the use of hearing aids, an increase in auditory cortex activation was coupled with reduced activation of the frontal cortex. This potentially suggests that hearing aids influence brain activity differently in challenging noise conditions, enhancing the temporal lobe activity associated with speech processing while reducing the activity in frontal lobes, possibly indicating a shift in cognitive processing strategies. This indicates that participant's ability to recall sentences was negatively impacted due to the challenges of inhibiting background noise, with most of the cognitive effort being allocated to differentiating speech from noise, leaving fewer cognitive resources available for storing and retrieving sentences. Our findings highlight the nature of the difficulties people with hearing loss experience in noisy situations even when they are wearing hearing aids. We hypothesize that these difficulties will improve with hearing aid use.

Category: Speech Perception

Poster #: 116

Audiovisual Speech Frequency Importance Weighting in Adults and Children

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Objectives: Prior research shows that adults' frequency importance functions shift to lower frequencies when visual speech is present because visual speech cues are more redundant with high-frequency acoustic speech cues. Although children also benefit from visual speech, it is unknown whether children's frequency importance functions show a similar shift. The goal of this experiment was to examine differences in frequency importance weighting between auditory-only and audiovisual conditions in adults and children with typical hearing.

Design: Auditory-only and audiovisual frequency importance weight functions were measured in 21 adults with typical hearing and (corrected-to-) typical vision. Stimuli included early acquired consonant-vowel-consonant words filtered into 6 one-octave bands centered at 0.25, 0.5, 1, 2, 4, and 8 kHz. On each trial, acoustic speech filtered to contain two pseudo-randomly chosen bands was presented and verbal responses were collected. Generalized linear mixed models with logistic link functions were used to fit accuracy data from each modality given the presence or absence of each band. The estimated log odds ratios (weights) for each band were analyzed in a model that included an interaction of modality and frequency band. To date, 14 children (7 to 12 years old) with typical hearing and (corrected-to-) typical vision have completed the same protocol, except that acoustic speech from three pseudo-randomly chosen bands was presented on each trial. Recruitment of children is ongoing.

Results: In adults, mean accuracy across all two-band combinations was 49% for auditory-only speech and 83% for audiovisual speech. Their auditory-only and audiovisual frequency importance weighting functions both showed a peak at 2 kHz with weights progressively declining for bands farther from 2 kHz. Weights in the audiovisual condition were significantly lower than weights in the auditory-only condition for the four highest frequency bands (1, 2, 4, and 8 kHz). In preliminary results from children, mean accuracy across all three-band combinations was 65% in auditory-only conditions and 78% in audiovisual conditions. As in adults, children's auditory-only and audiovisual frequency importance weighting functions both showed a peak at 2 kHz with weights progressively declining for bands farther from 2 kHz. There were trends in the children's results showing marginally lower weights in the audiovisual condition than the auditory-only condition for the three highest frequency bands (2, 4, and 8 kHz).

Conclusions: Results replicate previous findings that adults and children with typical hearing benefit from visual speech cues, that the 2 kHz region is particularly important for auditory speech perception in both children and adults with typical hearing, and that frequency importance functions in adults with typical hearing shift to lower frequencies when visual speech is present. Preliminary results suggest that children's frequency importance functions may also shift to lower frequencies when visual speech is present. One interpretation of these findings is that bands redundant with visual cues have less.

Category: Speech Perception

Poster #: 117

Performance of Spanish-English Bilingual Speakers on AzBio Sentence Tests

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Objectives: Our goal is to investigate whether a relationship exists between the language in which the AzBio sentence test is conducted for Spanish-English bilingual speakers and the accuracy in word identification. Hypotheses included: 1) bilingual speakers will perform better on the Spanish AzBio than the English AzBio for all speech in noise conditions, 2) bilingual speakers will exhibit comparable performance on the Spanish and English AzBio lists for the speech in quiet condition, and 3) later acquisition of the second language will predict poorer performance in the participants' second language.

Design: Participants included 14 adults with normal hearing between the ages of 18 and 89 years of age with Spanish and English fluency. Recruitment took place through mutual contacts and flyers throughout the University of South Florida campus. The hearing exam consisted of otoscopy, tympanometry, and pure-tone air-conduction thresholds from 0.5 to 8-kHz. Those with a pure tone average from 500-2000 Hz of greater than 25dB HL were excluded from the study. If tympanometry revealed results inconsistent with normal middle ear function, bone conduction was performed for confirmation. Participants completed the LEAP-Q questionnaire and the California Health Interview Survey (CHIS) to indicate dominant language. Two AzBio sentence lists were completed in Spanish and English in each of the +6, 0-, and -6-dB SNR conditions. Lists were randomly generated, and the language with which to start the testing was counterbalanced between participants.

Results: Our study revealed trends for better Spanish scores for all speech in noise conditions and similar performance on the Spanish and English AzBio lists for the quiet condition. Correlations were also performed to analyze if whether the dominant language influenced outcomes on the participants' primary and secondary language. Three significant relationships were found: 1) moderate positive correlation in the Spanish quiet condition ($r = .62$, $P = .018$), 2) moderate positive correlation in the Spanish 0dB SNR condition ($r = .63$, $P = .016$), and 3) moderate negative correlation in the English +6dB SNR condition ($r = -.63$, $P = .013$).

Conclusions: Those that prefer Spanish perform better in Spanish in quiet and the 0dB SNR condition compared to those who favor English. Additionally, those that prefer Spanish performed poorer in English at the +6dB SNR condition compared to those who favor English. There were no clinically or statistically significant findings based on age of secondary language acquisition and second language performance. Clinical implications of our study include: 1) performing appropriate speech perception measures (i.e. identifying language preference, avoiding ceiling effects, enhanced tracking of progress with amplification devices, and reducing testing time), 2) more accurately identifying cochlear implant candidates and avoiding contraindications to implantation, and 3) enhancing rapport with Spanish-English bilingual patients.

Category: Speech Perception

Poster #: 118

Examining Associations Between Speech-in-Noise Recognition, Stapedial Reflexes, and Olivocochlear Reflexes

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Objectives: The middle-ear muscle reflex (MEMR) and medial olivocochlear reflex (MOCR) modify peripheral auditory function to reduce masking. Therefore, elicitation of these reflexes may be beneficial for speech-in-noise (SIN) recognition. However, the MEMR and MOCR are typically measured in isolation in research studies. Our overarching research question was: how do the MEMR and MOCR contribute to SIN recognition? To answer this question, we used contralateral reflex elicitors intended to primarily elicit the MOCR (steady noise) or the MOCR and MEMR (pulsed noise). It was hypothesized that SIN recognition would be significantly correlated with the strength of the MEMR and with the strength of the MOCR. Additionally, it was hypothesized that SIN recognition would be highest in the presence of contralateral pulsed noise compared to steady noise. These hypotheses derive from our previous work.

Design: Forty-four healthy adults with normal hearing participated (35 females, age range: 19-29 years). Participants were recruited from a university campus. Measurements were obtained with and without contralateral acoustic stimulation (CAS), with the factors of level (50 and 65 dB SPL) and type (pulsed and steady). Strength of the MEMR was measured as the change in wideband absorbance from 500-4000 Hz with versus without CAS. Wideband absorbance was measured using an Interacoustics Titan tympanometer. Strength of the MOCR was measured as the change in transient-evoked otoacoustic emission (TEOAE) amplitude from 500-4000 Hz with versus without CAS. TEOAEs were measured using an Etymotic Research ER-10C probe. SIN recognition was measured as percentage correct for a modified version of the QuickSIN (signal-to-noise ratios ranging from 5 to 0 dB).

Results: Data from six participants were excluded due to poor-quality absorbance measurements or incomplete results. For the MEMR, there was a significant level x type interaction. Pulsed noise yielded significantly larger MEMR strength compared to steady noise, and this difference was significantly larger at 65 dB SPL compared to 50 dB SPL. In contrast, for the MOCR, there was no significant level x type interaction. 65 dB SPL yielded significantly larger MOCR strength than 50 dB SPL. There were no significant differences in MOCR strength between steady and pulsed noise. There was a wide range of SIN recognition scores across subjects. Contrary to hypotheses, MEMR strength and SIN recognition were not significantly correlated, and MOCR strength and SIN recognition were not significantly correlated. Additionally, there were no significant differences in SIN recognition scores across CAS conditions, contrary to the hypothesis.

Conclusions: The results suggest no significant associations between SIN recognition and the MEMR and MOCR, at least as measured and analyzed in this study. The lack of significant correlations does not appear to be explained by insufficient variability in the MEMR, MOCR, or QuickSIN measures. Performance on the QuickSIN may have been influenced by factors not accounted for in this study, such as attention and motivation. Our future work will examine MEMR and MOCR strength in narrower

frequency bands and across a wider range of stimulus levels, and we will continue to examine associations with SIN recognition.

VESTIBULAR

Category: Vestibular

Poster #: 119

Prevalence of Dyscapnia (Abnormal Carbon Dioxide Levels) in Vestibular Referrals

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Objectives: Dyscapnia, manifesting most commonly as hypocapnia, is a state of reduced blood carbon dioxide below 40 mmHg, induced by altered ventilation. Hypocapnia results in respiratory alkalosis, an alkaline blood pH, with altered tissue oxygen as well as reduced blood flow, resulting in altered neurologic function. Symptoms of hypocapnia include breathlessness, dizziness, nausea, lightheadedness, and presyncope/syncope. Clinicians in the Aerospace Medicine Program and the Aerospace Medicine and Vestibular Research Lab at Mayo Clinic designed this retrospective study for interprofessional education and referral quality assurance purposes. Because hypocapnic patients frequently present with non-localizing balance symptoms, the objective of this retrospective chart review is to assess the incidence of hypocapnia in patients who have had both vestibular assessment and consultations to evaluate their acid-base status using blood gas analysis and provocation testing.

Design: 792 patients were seen at Mayo Clinic by the Aerospace Medicine program for consultation via referrals from the Neurology, Internal Medicine, Psychiatry, and Audiology departments. 116 of those patients also underwent a vestibular examination, with 104 of them having their consultation assessing acid base status via blood gas testing scheduled after their vestibular assessments took place. During the consultation, a test is used to assess symptoms related to altered carbon dioxide homeostasis (Capnic Challenge Testing). The patient is instructed to increase his breathing rate as much as feasible for two minutes and indicate symptoms elicited on the Nijmegen questionnaire. Scores greater than 23 out of 64 indicate a high symptom load. Then, after the rapid breathing period, the patient is provided CO2 supplementation until subjective symptoms resolve. Four patients were chosen as case studies with the following profiles: two patients who were hypocapnic without vestibular pathology, a patient experiencing both hypocapnia and vestibular hypofunction concurrently, and a hypocapnic patient with post-concussion syndrome exhibiting vestibular symptoms without vestibular pathology.

Results: Patients who were referred for testing by their vestibular audiologist or neurologist were often found to be experiencing hypocapnia. Of the 116 patients seen jointly for Capnic Challenge testing and vestibular assessment, 74 patients (64%) had positive carbon dioxide challenge testing with subjective improvement in symptoms after carbon dioxide supplementation and chronic respiratory alkalosis on

arterial blood gas analysis. They had high scores (greater than 23 of 64) on the Nijmegen questionnaire, indicating that there is a strong likelihood these patients are experiencing signs and symptoms related to alterations in carbon dioxide levels. Hypocapnia was rarely the only medical condition these patients were found to have, as 38 of the 74 hypocapnic patients also had migraines and 21 of the 74 had postural orthostatic tachycardia syndrome (POTS); 17 had both POTS and migraines. Only 15 patients of the 74 had central or peripheral vestibulopathies.

Conclusions: CO2 supplementation, breathing exercises, and the temporary use of prescribed carbonic anhydrase inhibitors can improve dizziness and syncope in patients who are dizzy without vestibulopathies as well as those with vestibular disorders and secondary respiratory alkalosis. It is important that clinicians understand the condition and recognize hallmark symptoms that necessitate interprofessional referrals between audiologists, neurologists, and aerospace medicine specialists.

Category: Vestibular

Poster #: 120 **Mentored Student Research Poster Award**

Investigation of Postural Stability and Cochleovestibular Growth Rates in Patients with Neurofibromatosis Type 2

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Objectives: Neurofibromatosis type 2 (NF2) is an autosomal dominant condition resulting from mutation of merlin, a tumor suppressor gene, and is characterized by bilateral cochleo-vestibular schwannomas (CVS) and other nervous system tumors. The clinical presentation of NF2 includes tinnitus and hearing loss due to cochlear and retrocochlear dysfunction. However, the functional mechanisms of disequilibrium and vestibular dysfunction remain unknown. Moreover, the decline in functional balance in patients with NF2 poses a serious health concern due to associated risk for falls. The goal of this study was to characterize the longitudinal postural stability and the relationship between postural stability and CVS tumor growth rates (SGR) in patients with NF2.

Design: We evaluated 72 treatment naïve participants (age 28.9 ± 18.01 years; 32 males) with NF2 who were enrolled in a prospective natural history study (NCT00598351). All underwent annual assessments with a mean of 5 visits per patient. Postural stability was examined using computerized platform posturography (Neurocom; VIASYS, Inc) for the standard six sensory organization testing (SOT)

conditions. Linear regression models were used to determine the rate of change in postural stability change for each SOT condition and composite/sensory scores for those patients with multiple visits. Rates of postural stability change were then compared against CVS-SGR for each SOT outcome measure to determine the relationship between functional balance measures and CVS growth rates in patients with NF2.

Results: Preliminary analyses identified declines in functional balance across all sensory modalities (somatosensory, visual and vestibular), with significant declines in postural stability for SOT conditions reliant upon vestibular sensory mechanisms (conditions 5 and 6). While an ANCOVA fails to reveal any significant differences in the loss of postural stability across all conditions, linear regression models identified significant negative relationships between total CVS-SGR and the composite vestibular sensory analysis score (p=0. 012), as well as conditions 5 (p=0.016), and 6 (p=0.041).

Conclusions: Our findings indicate a measurable impact of CVS growth on balance function in individuals with NF2, specifically highlighting a significant relationship between the loss of postural stability when relying on vestibular cues and CVS-SGR. The relationship between total spinal and visual tumor burden will be reported to further investigate their effects on posturography conditions reliant on those sensory modalities (conditions 2 and 4). While the hallmark symptoms of NF2 largely revolve around cochlear disturbances leading to tinnitus and hearing loss, our study underscores the significant relationship between CVS tumor growth rates and compromised balance function.

Category: Vestibular

Poster #: 121 **Mentored Student Research Poster Award**

Cisplatin-Induced Vestibulotoxicity in a Clinically Relevant Mouse Model

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Objectives: Despite its effectiveness in treating cancer, cisplatin can induce cochleotoxicity in up to 50-60% of patients. However, the vestibulotoxic potential of cisplatin remains unclear. Reported incidences are highly variable; vestibular symptoms are often underappreciated, and objective measures of vestibulotoxicity are frequently limited to assessment of horizontal semicircular canal function. As a result, many patients experiencing vestibulotoxicity likely go unevaluated.Our lab previously developed and optimized a multi-cycle model of cisplatin administration in mice that results in hearing loss similar to that observed clinically with virtually no mortality. The purpose of this study was to comprehensively

characterize the functional and morphological consequences of cisplatin on the entire vestibular periphery in this mouse model.

Design: Adult CBA/CaJ mice were randomly assigned to control and cisplatin-treated groups. Cisplatin-treated mice received three consecutive cycles of once-daily intraperitoneal injections of 4 mg/kg cisplatin for four days followed by a 10-day recovery period, for a cumulative cisplatin dose of 48 mg/kg. All mice underwent VsEP testing prior to cisplatin administration, after the final cycle of cisplatin, and 6 months after treatment cessation. Thresholds were designated as the stimulus level halfway between the lowest level at which a repeatable response was obtained and level at which no response was obtained. Mice also underwent vestibulo-ocular reflex (VOR) testing and vestibular afferent single-unit recordings 6 months after treatment cessation. For VOR testing, eye velocity signals in response to sinusoidal head rotations and translations were recorded using infrared eye tracking. Rotational and translational VOR gains and phases were calculated from these signals. For single unit recordings, afferents' spontaneous activity and responses to head rotations and translations were recorded. Afferent regularity was determined by calculating normalized coefficient of variation of interspike intervals (i.e., CV*). Gains and phases relative to head velocity were calculated at 1Hz.Following functional testing, temporal bones were extracted, fixed, and decalcified. Utricles, saccules, and ampullae were micro-dissected and immunostained with hair cell and afferent neuron markers.

Results: VsEP thresholds were significantly elevated in cisplatin-treated mice after the final cycle of cisplatin and continued to worsen significantly 6 months after treatment cessation. Consistent with these findings, utricular and saccular hair cell densities were reduced in cisplatin-treated mice. While no significant differences in vestibular afferent spontaneous firing rates were observed, cisplatin caused changes in rotational VOR gain and decreases in the irregularity of horizontal semicircular canal afferents.

Conclusions: Our results demonstrate cisplatin's potential to adversely and differentially affect the otolith organs (i.e., utricle, saccule) and semicircular canals, and they suggest that the vestibulotoxic potential of cisplatin is likely underestimated. Clinically, objective vestibular testing is often limited to assessment of horizontal semicircular canal function, leaving the status of 4/5 vestibular end organs largely unknown. Future studies will characterize the vestibular morphology in temporal bones from patients treated with cisplatin and compare these findings to those obtained in our mouse model. Together, these results may emphasize the need for more comprehensive vestibular testing and monitoring in patients treated with cisplatin.

Category: Vestibular

Poster #: 122 **T35 Research Trainee Poster**

Reliability of Audiovisual Temporal Binding Window Measurements

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Objectives: The temporal binding window (TBW) is the period of time over which two stimuli presented at different times are perceived as one event. This helps quantify how the brain integrates different stimuli in the temporal domain. A prolonged TBW is associated with conditions such as schizophrenia and dyslexia, and a narrowed TBW is associated with musical or athletic proficiency. In addition to a basic science tool, the TBW may thus be useful in identifying and quantifying progression of disease as well as the level of ability in otherwise normal people. However, the TBW has not been validated with respect to test-retest reliability, reducing its current utility for scientific and clinical investigations. Here, we measured the reliability of audiovisual temporal binding windows in normal subjects.

Design: Temporal binding window measures were collected in 15 participants (ages 19 - 58) with normal hearing and no history of vestibular disease. A 10 ms red flash and a 10 ms, 1000 Hz tone were presented at 11 stimulus onset asynchronies: -400, -300, -200, -100, -50, 0, 50, 100, 200, 300, and 400 ms (negative numbers indicate flash first and positive numbers indicate beep first). Each participant was tested twice at separate visits (at baseline, and on average 7 days later) using a method of constant stimuli paradigm. Each subject was tested 10 times at each of the 11 stimulus asynchronies. Psychophysical curves were generated using a generalized linear model (GLM) and a Bayesian model.

Results: Results using both Generalized Linear Model (GLM) and Bayesian fits suggest that TBW consistency was moderate across visits at the group level ($P = 0.1394$, $P = 0.6061$ respectively) when using linear regression analysis. Bland-Altman plots indicated that the departure from consistency was related to performance in a few specific subjects. The subjects did not differ from others in their KSS scale ($P = 0.5689$). There were no clear explanations for differences in performance, including sleepiness (KSS).

Conclusions: Our data demonstrate good test-retest reliability for TBW measurements of audiovisual synchrony. This suggests that this measure could be a valid tool for evaluating and comparing clinical populations. Further research and analysis will include a couple of improvements: acquiring a larger sample size to account for variance and increasing the number of trials per time interval to improve estimation of the psychometric curve.

Category: Vestibular

Poster #: 123

Assessing Balance Intervention Outcomes in Older Adults with Hearing Loss

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Objectives: Individuals with hearing loss, especially those with more severe degrees, have a higher risk of falls and fall-related injuries, which escalates with age. Examining the effectiveness of balance intervention programs in older adults with hearing loss is crucial for improving clinical outcomes and

reducing fall risk. While various balance intervention and exercise programs reduce falls, it is unclear which individuals benefit the most. This study aimed to assess the impact of a balance intervention program on older adults' fall risk and balance and identify the key predictors of balance intervention outcomes. We hypothesized that participants would show reduced postural sway and fall risk after completing the balance intervention and that severity of hearing loss would predict intervention outcomes.

Design: Twenty-nine older adults (60-90 years) with concerns about falling were recruited to participate in the study. All participants completed a hearing evaluation, the balance intervention program, and pre- and post-assessments. The balance intervention, A Matter of Balance (AMOB), is an evidence-based program that incorporates active learning discussions and activities along with exercise training to address fear of falling and fall prevention in older adults. Pre- and post-intervention balance and fall risk was assessed via measures of postural sway (i.e., center of pressure path length) and subjective questionnaires. Questionnaires evaluated participants' fall risk, balance confidence, and level of physical activity.

Results: Results revealed slight balance-related benefits following the completion of the AMOB program. Postural sway, number of falls within the past year, and hearing loss were identified as significant predictors of balance intervention outcomes. Individuals with greater postural sway (i.e., higher fall risk) at baseline demonstrated the most benefit from the AMOB program. Furthermore, more benefit from intervention was gained by participants having multiple risk factors. Those who reported at least 1 fall in the past year and who had greater severity of hearing loss showed more benefit than those without a history of falls. Thus, older adults at higher risk of falls demonstrated the most significant benefit.

Conclusions: Our results inform clinical practice by clarifying who may benefit most from balance intervention programs. Routine fall risk screening in older adults is crucial. Identifying individuals at higher fall risk allows us to recommend targeted balance interventions, effectively reducing the risk of falls and related injuries.

Category: Vestibular

Poster #: 124

Vestibular and Balance Function in Individuals with Down Syndrome

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Objectives: The purpose of this study is to determine the prevalence of vestibular dysfunction in individuals with Down syndrome. Up to 80% of individuals with Down syndrome have hearing loss at some point across their lifespan, yet few studies have evaluated vestibular and balance function. We hypothesized that individuals with Down syndrome with hearing loss will have some degree of vestibular loss. We further hypothesized that greater severity of vestibular dysfunction will be related to greater severity of hearing loss; however, this

relationship could be confounded by the presence of middle and/or inner ear anatomical differences reported in individuals with Down syndrome. Additionally, greater severity of vestibular loss has been linked to greater balance impairments. A similar relationship is hypothesized in individuals with Down syndrome. This study represents an important first step in characterizing the relationship between vestibular loss, balance difficulties, middle ear dysfunction, and hearing loss in individuals with Down syndrome.

Design: All participants completed the video-Head Impulse Test (vHIT) to assess horizontal semi-circular canal function. Cervical and ocular Vestibular Evoked Myogenic Potential (cVEMP and oVEMP) testing using both air conduction stimuli (ACS) and bone-conducted vibration (BCV) were completed to assess saccule and utricle function, respectively. Behavioral audiometric threshold, tympanometry, and wideband acoustic immittance (WAI) testing were completed to assess cochlear and middle ear function. Balance measures included: gait speed, Timed-Up and Go, and single leg stance. The study sample included 10 individuals with Down syndrome (20 ears) and 11 age-matched neurotypical control participants (22 ears) who denied vestibular symptoms, had normal audiometric thresholds, and normal middle-ear function. Recruitment is ongoing.

Results: All control participants had present VEMP responses and normal vHIT. Some degree of vestibular loss was observed in 70% of participants with Down syndrome. For vHIT, 60% of individuals with Down syndrome had normal responses, three individuals had bilateral vestibular loss and one individual had unilateral vestibular loss. VEMP response rates increased with BCV (cVEMP: 85%, oVEMP:55%) compared to ACS (cVEMP: 22%, oVEMP: 28%), which is attributed to the presence of middle ear dysfunction (n = 6 ears). Further analyses are planned using WAI to explain the differences in VEMP responses using ACS vs BCV. The control group performed significantly better on all balance measures ($p < .03$) except preferred gait ($p = .109$). Balance ability significantly correlated with degree of vestibular loss ($p < .033$) for all subjects.

Conclusions: There is a high rate of vestibular dysfunction in individuals with Down syndrome, which can lead to difficulties with balance. The improvement in VEMP responses using BCV is attributed to a large number of individuals with middle ear dysfunction. Accounting for middle-ear dysfunction when selecting test stimuli for individuals with Down syndrome is essential for accurate vestibular assessment.

AUDITORY PROCESSING / LISTENING EFFORT

Category: Auditory Processing/Listening Effort

Poster #: 125

Auditory Brainstem Neural Variability, Autistic Traits, and Sensory Sensitivities

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Objectives: Understanding the contributions of neural variability, measured by trial-to-trial fluctuations in an evoked neural response, to behavior has been particularly interesting to researchers since findings suggest that decreased cortical neural stability correlates with heightened autistic traits. This correlation

has led some researchers to hypothesize a causal link between increased neural variability and heightened autistic traits and sensory sensitivities. In the brainstem, elevated neural variability evoked from monaurally presented auditory stimuli is associated with poorer syntactic performance, and some studies have found group differences in neural variability between autistic and nonautistic individuals. Yet, the potential relationship between neural variability in the brainstem and autistic traits and sensory sensitivities remains unexplored. The current study sought to elucidate (1) whether auditory brainstem responses (ABRs) neural variability elicited by click and speech stimuli differed depending on when analyzed post-stimulus onset and by stimulus type, (2) if neural variability was significantly related to sensory sensitivities evaluated through the parent-report Sensory Profile (SP) (3) and whether neural variability predicted the spectrum of parent-reported autistic traits, quantified using the Autism Quotient (AQ) and the Social Responsiveness Scale, Second Edition (SRS-2) among a combined group of nonautistic and autistic school-age children.

Design: Forty-four children, including 18 autistic and 26 nonautistic peers aged 6-16.9 years, participated. Before electrophysiological recording, participants underwent a routine hearing evaluation and an IQ assessment. Parent(s) completed the SP, AQ, and SRS-2. ABRs were evoked by binaural presentation of clicks and a 40 ms synthetic /da/ stimulus and recorded ipsilaterally using a two-channel montage via scalp electrodes. Two waveforms, each comprised of 3000 sweeps, were correlated together for the entire click response (1-8 ms) and the various response components of the sABR: the complete response (0-55 ms), the onset (5-10 ms), the frequency-following (22-40 ms), and the offset (45-50 ms) responses. An repeated measures ANOVA was conducted to determine if the degree of neural variability differed by response components. Linear regression models were constructed and tested to determine if neural variability significantly predicted sensory sensitivities or autistic traits.

Results: Significant differences in neural variability were found among the response components analyzed. Neural variability in the onset sABR and click ABR were not significantly different, aligning with existing literature that the two components are analogous. No meaningful relationships emerged between neural variability and sensory sensitivities. In contrast, neural variability of the sABR offset response and entire click ABR predicted autistic traits after controlling for verbal IQ. Specifically, increased neural variability was associated with heightened total scores on AQ and SRS-2.

Conclusions: The study challenges current methods by highlighting the relevance of analyzing different response components within the sABR, instead of only the FFR, and advocates for a paradigm shift from case-control studies toward predictive modeling studies, especially in heterogeneous conditions like autism. Although brainstem neural variability did not predict sensory sensitivities, it emerged as a predictor of autistic traits. By further understanding neural variability's complex relationship with behavioral traits, researchers may be able to facilitate a more comprehensive understanding of individual differences in auditory processing and autistic traits.

Category: Auditory Processing/Listening Effort

Poster #: 126

Assessment of Listening Effort and Fatigue in Daily Life

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Objectives: Individuals with hearing impairment report experiencing higher levels of listening effort and fatigue during daily life than age-matched individuals with normal hearing. Since findings from the laboratory have been shown to be poor predictors of real-life listening experiences there is a need for measures that can be used to evaluate listening effort and fatigue in daily life. Recent studies have measured physiological responses to sound exposure during daily life and found that higher sounds pressure levels and lower signal-to-noise levels were associated with increased heart rate and lowered heart rate variability. The present study aims to establish physiological measures that predict self-reported listening effort and fatigue during daily life. Furthermore, the moderating effects of cognitive abilities, personality traits, perceived stress, perceived fatigue, supra-threshold abilities, lifestyle and health on the development of listening effort and fatigue are investigated.

Design: Sixty hearing aid users will be recruited to participate in a four-week field trial, during which physiological responses are continuously recorded via Empatica Embrace Plus wristbands, ambient acoustics are recorded every 20 seconds via the participants' own hearing aids, and self-reported momentary assessments are provided by the participants via an app throughout the day. The momentary assessments include reports of the participants' listening activity, as well as ratings of the perceived importance to hear well, hearing difficulty, listening effort and mental tiredness. The participants attend two test visits (pre- and post-field trial). During the first visit the participants' personality traits, perceived fatigue, and perceived stress are assessed. Relevant background information is gathered via a questionnaire. Additionally, their supra-threshold abilities are evaluated. The questionnaire assessing perceived fatigue is filled out weekly during the field trial. During the second visit, the questionnaire regarding perceived stress is repeated, perceived noise annoyance from traffic and neighbor noise is assessed, and cognitive abilities are evaluated. Factor analysis will be performed for dimensionality reduction of the variables related to participant characteristics. Associations between physiological responses, ambient acoustics, and momentary assessments, as well as the potential influence of participant characteristics will be investigated using multi-level regression models and time-series analyses.

Results: Data collection is in the beginning stages and is expected to be completed in March 2024. Preliminary results will be presented.

Conclusions: The present study is the first to combine longitudinal objective data, that is physiological responses and ambient acoustics, with self-reported momentary assessments obtained during the hearing aid users' daily life. The outcomes of this study are ultimately expected to contribute to ecologically valid methods of assessing the effects of hearing aid signal processing on listening effort and fatigue.

Category: Auditory Processing/Listening Effort

Poster #: 127 **T35 Research Trainee Poster**

Attentional Capture, Rehearsal Interference, and the Irrelevant Sound Effect

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Objectives: Irrelevant background sounds like speech, music, and traffic noise often impact children's ability to remember new strings of information. This irrelevant sound effect occurs on auditory and nonauditory memory tasks, implicating central cognitive mechanisms. While the mechanisms are not yet fully understood, significant child/adult differences in the irrelevant sound effect have been observed. Since cognitive skills like working memory, rehearsal, and attentional control all mature throughout childhood, immaturity in these skills may underlie younger children's greater susceptibility to irrelevant sounds. However, children's irrelevant sound effect is typically assessed with gated speech rather than under the full range of background sound conditions studied in the context of speech recognition. Identifying which background sounds interfere with children's serial recall may shed light on the cognitive mechanisms supporting performance in background sounds, more generally. For example, if speech content alone is sufficient to elicit the irrelevant sound effect, this would suggest that irrelevant sounds interfere with rehearsal, a form of private speech used to maintain items in short-term memory. Moreover, if auditory distraction in children is due solely to rehearsal interference and not attentional capture, the onset of gated sounds - whether speech or noise - should not further impact performance.

Design: Participants were 28 children with typical hearing ages 5-8 years. Participants saw a series of 3, 4, or 5 pictures drawn from a set of nine nameable concrete objects (e.g., flag, flower, owl)... Participants were instructed to select the images in the order of presentation on a touchscreen. Participants completed the serial reconstruction task in quiet and under two manipulations of background sound: (1) type of background sound (narrow band noise and two-talker speech) and (2) background continuity (gated and continuous).

Results: Serial recall was better in silence than in each competing background sound condition; thus, each combination of type and continuity of sound elicited an irrelevant sound effect. However, the irrelevant sound effect was equivalent across the four conditions. In other words, noise-related factors did not appear to impact performance differentially. Rehearsal was attempted at similar rates across all conditions. Therefore, the effect of rehearsal status was examined by collapsing across all the competing background sound conditions. An interaction emerged such that competing background sound conditions were particularly detrimental to those children who relied on the more complex cumulative rehearsal strategy than children who used a simpler fixed rehearsal or no rehearsal.

Conclusions: Background noise interferes with children's cumulative rehearsal strategies. However, it is unclear, based on these data, whether greater susceptibility to auditory distraction can be attributed solely to rehearsal interference as narrowband noise also evoked an irrelevant sound effect. One interpretation is that rehearsal consumes attentional resources, so any background sound condition that captures attention will disrupt rehearsal with a cascading impact on serial recall.

Category: Auditory Processing/Listening Effort

Poster #: 128 **T35 Research Trainee Poster**

Linking TBI and Auditory Dysfunction with Time Compressed Digits

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Objectives: Military service members are at an increased risk for auditory processing disorders (APD) due to occupational risk factors such as traumatic brain injury (TBI). Auditory deficits among these patients are heterogenous and may affect processing domains such as temporal precision, temporal pattern recognition, auditory working memory, and more, necessitating an extensive test battery. The clinical burden of triaging and diagnosing APD following TBI could be mitigated via a screening measure with high sensitivity and specificity for APD. The goal of this project was to develop and test such a screening tool: the Time Compressed Digits (TCD) test. Participants are asked to recall a series of numbers that are presented in multiple conditions including with and without background noise, with and without temporal compression (e.g., rapid speech), and with and without the insertion of silent intervals meant to allow for additional processing time of rapid speech. The TCD test is well suited to identify auditory processing deficits because it requires several domains of auditory function (temporal precision, pattern recognition, low redundancy speech, auditory processing speed and information recovery, and speech understanding in noise) in addition to being quick, repeatable, ecologically valid, and with automated administration and scoring. The aim of this study was to compare TCD test performance in a group of Veterans with a history of TBI and normal hearing sensitivity with an age-matched, gender-matched control group. It was hypothesized that participants with history of TBI would demonstrate poorer performance on the TCD compared to controls, and that performance on specific test measures would predict an APD diagnosis.

Design: 36 individuals with previous TBI and 26 control participants with no history of TBI or blast exposure participated. Testing included audiometric assessment, six clinical APD diagnostic measures, and 16 different TCD conditions. Time-compressed stimuli were generated by compressing a string of seven spoken digits by 80% using a pitch-synchronous, overlap and add (PSOLA) procedure. Silent gaps were inserted into the compressed signal at regular intervals with durations of 0, 20, 40, 80, 120, and 160 ms and a random aperiodic condition. Uncompressed and compressed stimuli with and without silent gaps were presented in quiet and in background noise, with 30 trials presented per condition.

Results: Preliminary analyses revealed that TBI participants perform significantly poorer than controls on TCD conditions with 80 and 120 ms gaps presented in quiet and in the 160 ms gap condition presented in noise. A significant correlation was found between performance on the compressed 160 ms gaps with background noise condition and the number of APD test measures failed. ROC analyses revealed the compressed 160 ms gaps with background noise condition led to an area under the curve of 0.829.

Conclusions: Participants with previous TBI demonstrated poorer performance on specific TCD conditions when compared to controls. The largest group differences occurred at longer silent gap durations. Analyses also revealed high sensitivity and specificity for specific TCD conditions in detecting APD suggesting potential utility as a screen tool for APD in patients with TBI.

Category: Auditory Processing/Listening Effort

Poster #: 129

Speech-in-Noise and Complex Tone Perception in Children With/Without Listening Difficulties

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Objectives: Speech perception in noise (SPIN) has been proposed as an alternative or additional form of standard audiological assessment. For children with listening difficulties (LiD), but clinically normal audiograms, SPIN has been proposed as a definitive metric of auditory processing disorder (APD), although various suprathreshold, non-speech tests are also used. Given the reported impact of SPIN as an auditory test, a question is what form of SPIN to use. Is it speech as a stimulus that makes SPIN special, is it the complexity of the task, or is it some other aspect of psychometric testing? To begin answering these questions, in this study we tested the same groups of children with LiD or without LiD (typically developing, TD) on 5 tasks, 3 SPIN identification and 2 multi-tone discriminations found to predict SPIN in adults. The specific hypotheses were that (i) SPIN tasks would be more sensitive and specific for LiD than non-speech tasks, and (ii) SPIN tasks with spatial cues would be more sensitive and specific for LiD than a co-located task.

Design: Children with normal tone sensitivity (all octave frequencies 0.25-8.0 kHz ≤ 20 dB, bilaterally) participating in Wave 2 of the longitudinal Sensitive Indicators of Childhood Listening Difficulties project were divided into LiD (n=52) or TD (n=48) based on caregiver evaluation (ECLiPS). Here, all children completed the BKB-SIN (speech in 4 talker babble; Etymotic), LiSN-S (sentences in distractor sentences, with and without spatial/talker cues; Phonak), PART-CRM (target words of Coordinate Response Measure sentences in masking sentences, with and without spatial cues; UCR Brain-Game Center), PART-STM (detection of tonal spectrotemporal modulation; UCR B-GC), and auditory figure-ground (detection of temporally coherent multi-tonal chords among random chords). Results were normalized (age, z-score), compared by group (TD, LiD), correlated with cognitive performance (NIH Toolbox), and subject to ROC analyses.

Results: TD performance surpassed LiD performance by group on all SPIN and tonal tasks, but the difference was not significant on either of the tonal tasks. Spatially separated sources and different talker cues were mostly more advantageous for the TD children, but no significant spatial advantage was found for TD children in the LiSN-S. ROC curves generally showed higher sensitivity and specificity for predicting listening ability in the speech tasks than in the tonal tasks. The BKB-SIN was the most accurate predictor of all tests (AUC: 0.88; Sensitivity: 0.71, Specificity: 0.83).

Conclusions: SPIN performance was a better predictor of LiD than tonal discrimination. TD children performed better than children with LiD on SPIN tasks that included cues. However, spatially cued tasks did not in general show additional benefit to co-located targets and maskers for predicting LiD in ROC analysis. These results suggest that BKB-SIN is a sensitive and specific test for identifying and quantifying listening difficulties in children.

Category: Auditory Processing/Listening Effort

Poster #: 130

Effect of Noise, Dysphonia and Cognitive Functions on Speech Perception

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Objectives: Classroom noise hinders children's speech understanding and negatively impacts teacher's voice quality. Dysphonia, a common voice disorder experienced by teachers, adds complexity by further degrading the speech signal. These challenges also raise cognitive demands, impacting attention, and working memory, while also increasing listening effort. The current study investigated the impacts of noise and dysphonia on children's word recognition and listening comprehension. Additionally, we investigated effects on both objective and subjective listening effort. We hypothesized that both noise and dysphonia would differentially affect speech-related tasks and increase listening effort. Noise and dysphonia voice were expected to have the greatest impact on listening comprehension, due to greater task complexity. We will utilize the outcomes of cognitive assessments to examine their relationship with task type, noise levels, and voice quality, aiming to assess their contribution to cognitive demands.

Design: Listeners were 26 children (8-12 yrs.), who were native English speakers with normal hearing. Closed-set word recognition and listening comprehension were measured as a function of signal-to-noise ratio (SNRs), and voice quality (normal or dysphonic). Word recognition was assessed using the Word Intelligibility by Picture Identification test (WIPI) and comprehension was measured using the Test for Reception of Grammar (TROG-2). Speech was recorded by a female actor using normal and mimicked dysphonic voice. Target speech was combined with pre-recorded classroom noise at two fixed SNRs, -8 dB and -12 dB. Listening effort was measured via self-report and response time. NIH toolbox was used to measure working memory and selective attention.

Results: Preliminary results for the word recognition test indicated a main effect of SNR, with decreasing SNR leading lower accuracy. In contrast, listening comprehension scores were significantly affected by both SNR and voice quality Particularly, the combination of the lowest SNR and a dysphonic voice resulted in a significant decrease in accuracy. With respect to cognitive abilities, children with higher working memory exhibited significantly better performance on the comprehension task only. Analysis of subjective listening effort revealed main effects of both SNR and voice quality in both tasks, with higher levels of perceived effort reported for the lower SNR and the dysphonic voice. Children with greater selective attention reported greater effort. Response time analysis demonstrated that children took more time to respond when the SNR was lower (word recognition task only) and when the speech was dysphonic (in both tasks). However, children with greater selective attention required a shorter response time for both tasks.

Conclusions: Preliminary analyses suggest children's recognition and comprehension were differentially impacted by noise and voice quality. Noise alone significantly reduced word recognition accuracy,

whereas the dysphonic voice exacerbated listening comprehension. Despite these differences, children reported increased listening effort for both tasks when noise and dysphonia were present. These findings suggest that simple tests of word recognition may not fully capture the impact of poor voice quality in noise. Our results highlight that teachers' voice quality may impede children's understanding of more complex tasks. Additionally, the role of working memory should be considered an influencing factor in these effects.

Category: Auditory Processing/Listening Effort

Poster #: 131

Multi-Talker Speech Segregation Based on Covariation of Voicing Cues

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Objectives: Studies have separately established the importance of differences in voice fundamental frequency (F0) and level (L) for segregating the speech of one talker from others speaking at the same time. In natural speech, however, these cues often covary. In emotive speech, for example, F0 and L will tend to increase or decrease together depending on whether the talker wishes to express they are happy or sad. Similarly, F0 will tend to increase as the talker raises the level of their voice to be heard over loud noise (Lombard effect). This study undertook to determine how listeners might use the natural covariation of F0 and L to segregate the concurrent speech of two talks. Three possibilities were tested: (1) listeners attend only to one cue, F0 or L, (2) listeners use both cues but assume they are statistical independent, (3) listeners make use of the covariation in cues.

Design: Eleven young, normal-hearing adults, recruited via flyers posted throughout the University of South Florida campus, participated in a single-interval, two-alternative, forced-choice talker identification task for which target talkers A and C differed in mean voice F0 and L (mean F0 and L for A less than C). A third talker B with mean voice F0 and L midway between the two targets served as distracter. The stimuli were naturally-spoken, recorded sentences drawn at random without replacement for each talker on each trial from 199 neutral exemplars of the Emotional Speech Database (https://arxiv.org/abs/2105.14762). The sentences were processed to produce three conditions of covariation between F0 and L for the talkers: (1)-Positive; F0 and L increasing together, (2) Independent; zero covariation, (3)-Negative; F0 increasing with decreasing L.

Results: Large individual differences in performance were observed, ranging from near chance to near perfect for the task. Six individuals performed best in the negative condition (5 at a $p<0.01$, 1 at a $p<0.10$) consistent with the use of covariation of the cues. Four individuals showed no statistically significant differences across conditions consistent with the use of a single cue, and one individual performed best in the independent condition, consistent with the use of both cues treated as varying independently of one another ($p<0.001$).

Conclusions: The findings suggest that individual differences in the ability to use voice F0 and L covariation might explain why certain individuals in everyday listening struggle more than others segregating the concurrent speech of talkers. A better understanding of the use of voice cue-covariation in speech segregation tasks for both normal-hearing and hearing-impaired individuals could lead to more informed hearing healthcare for those who report difficulty understanding speech in background noise.

Category: Auditory Processing/Listening Effort

Poster #: 132

Auditory Working Memory Affects Self-Perceived Listening Ability in Older Adults

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Objectives: Older adults often report difficulty hearing, especially when listening in acoustically complex environments. Hearing difficulties are known to be influenced by degree of hearing loss (e.g., greater degrees of hearing loss resulting in greater hearing difficulty). However, degree of hearing loss is not always predictive of self-perceived hearing abilities. For example, older adults with normal to near normal pure-tone thresholds have reported greater degrees of hearing difficulty relative to younger listeners. Age-related declines in cognitive processing, such as working memory, have been suggested to contribute to self-perceived hearing difficulties reported by older adults. Working memory temporarily stores sensory input for immediate use in tasks such as speech perception and language comprehension. Good working memory capacity is especially important to speech perception when listening in acoustically complex or adverse conditions. It is well-established that poorer working memory is related to poorer speech-in-noise performance among older listeners with hearing loss. However, little is known about the relation between working memory and self-perceived listening abilities in older adults. The present study examined the role of pure-tone hearing and auditory working memory in the self-perceived listening abilities of older adults.

Design: Twenty-five adults 54-89 years participated. Participant pure-tone hearing varied from normal (≤25 dB HL) to mild to moderate sensorineural hearing losses. Self-perceived hearing and listening abilities were assessed using the Adult Auditory Performance Scale (AAPS). The AAPS is a 36-item questionnaire that asks listeners to rate their listening difficulty in six auditory environments, including quiet, ideal, noise, multiple inputs, auditory memory sequencing, and auditory attention span. Higher scores indicate greater listening difficulty. AAPS scores were assessed for the noise subscale, an easy listening subscale (average of the quiet and ideal conditions), and a complex listening subscale (average of the multiple inputs, auditory memory sequencing, and auditory attention span conditions). Auditory working memory was measured using the Word Auditory Recognition and Recall Measure (WARRM). The WARRM measures word recognition in quiet concurrently with word recall using a listening span paradigm. Specifically, the 100 monosyllabic words are parsed into five listening span set sizes (i.e., 2, 3, 4, 5, and 6). Five trials of each span size are completed resulting in a word recognition score based on the percentage of words recognized correct, and a recall score based on the percentage of words correctly recalled.

Results: Results revealed that older adults perceived significantly greater listening difficulty for noisy conditions compared to the complex and easy listening conditions. Similarly, significantly greater listening difficulty was observed for complex listening compared to easy listening. Results revealed that auditory working memory was significantly correlated with self-perceived listening difficulty. Specifically, participants with poorer WARRM recall scores exhibited greater degrees of listening difficulty in noise, complex listening, and easy listening conditions. Linear regression revealed that auditory working memory was a significant predictor of listening in noise and complex listening, whereas pure-tone hearing was a significant predictor of easy listening.

Conclusions: Results support the conclusion that poorer auditory working memory contributes to poorer self-perceived listening ability in older adults, especially in difficult conditions.

Category: Auditory Processing/Listening Effort

Poster #: 133

Investigating Spatial Release from Listening Effort

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Objectives: Noisy environments are difficult listening environments for everyone, even those with normal hearing thresholds. Binaural hearing provides benefits in these environments, such as spatial release from masking. Spatial release from masking is the improvement in speech understanding with spatial separation between the target (signal of interest) and maskers (competing sounds). A listener achieves this by attending to a target and ignoring maskers with the help of binaural benefits such as head shadow, squelch, and redundancy. Spatial separation between target and maskers improves performance and may also provide cognitive advantages by reducing listening effort. Listening effort is the dedication of cognitive resources to complete an auditory task. While spatial release from masking is known to improve performance in challenging listening environments, there is not yet a consensus in the effort domain of perception if spatial release from listening effort occurs. We hypothesized that individuals with normal hearing experience the binaural benefit of spatial release from listening effort.

Design: Sixteen adults with normal hearing were included in this study. They listened to coordinate response measure (CRM) sentences spoken by a female talker among two interfering female talkers over headphones, with spatial configurations simulated using head-related transfer functions. The target was always presented in front (0 degrees azimuth) and interfering talker location was varied; interferers were either in front (maskers co-located with target) or to the right (90 degrees azimuth, maskers spatially separated from the target). Test ear was also varied, with a monaural condition (left ear, opposite the maskers) and binaural condition (both ears). Pupil size was monitored across these four conditions as an index of listening effort. We examined the contributions of head shadow, squelch, and redundancy to potential spatial release from listening effort. Target-to-masker ratios were chosen for each individual so that participants performed similarly across all four conditions.

Results: Contrary to the hypothesis, pupil size significantly increased, rather than decreased, with spatial separation between talkers in binaural conditions ($p < 0.05$). Additionally, examination of the

comparisons related to the components of spatial release from masking revealed that this increase in listening effort emerged with squelch. When the ear closer to the interferers was added in the binaural condition for spatially separated target and interferers, effort increased.

Conclusions: Our results suggest that in this paradigm, spatial release from effort was not observed, and in fact, effort increased with spatial separation between talkers. One possible explanation is that the target-to-masker ratios used in this experiment impacted the results. The target-to-masker ratio needed to match performance in the binaural condition with spatial separation between target and maskers was significantly poorer than in other conditions. It is also possible that the increased effort reflects useful directed attention to the target talker when there are spatial cues. Better understanding of listening effort in individuals with normal hearing gives a more holistic perspective on speech perception and is a step toward understanding listening effort in these environments for individuals with hearing loss. [Research funded by NIH K01-DC018064 (KDM).]

Category: Auditory Processing/Listening Effort

Poster #: 134

Effects of Selective Inner Hair Cell Loss and Cochlear Synaptopathy on an Intensity Increment Detection Tasks in the Chinchilla

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Objectives: Auditory intensity coding is essential for perceiving and coding complex acoustic stimuli, such as speech. These signals are considered complex in part due to rapid fluctuations along the intensity and temporal domains. Temporal processing ability is thought to be negatively impacted by age-related or noise-induced hearing loss. It has been suggested that deficits in temporal coding or intensity detection ability likely contribute to speech processing deficits in damaged ears. The current study aimed to evaluate chinchilla sensitivity to intensity differences with an intensity increment detection (IID) psychophysical task following carboplatin induced selective inner hair cell (IHC) loss or noise induced cochlear synaptopathy. The main hypothesis is that intensity coding deficits may be the result of peripheral damage, specifically related to IHC.

Design: Young adult chinchillas were used for this study. Hearing sensitivity and cochlear non-linearities were assessed via Auditory Brainstem response (ABR) thresholds, distortion product otoacoustic emissions (DPOAEs) and psychophysical pure tone thresholds in quiet. Suprathreshold ABR wave 1 was also measured to assess cochlear output. Chinchillas were conditioned to respond to intermittent changes in intensity to an otherwise continuous reference narrowband noise. IID performance was assessed at 1, 2, 4, 8, and 12 kHz center frequencies and at three continuous reference noise levels, low (20 dB SPL), moderate (50 dB SPL) and high (70 dB SPL). The low-level noise was initially increased by 20 dB SPL, the moderate-level noise initially increased by 15 dB SPL and the high-level noise initially increased by 10 dB SPL. An automated method of limits procedure was used to determine IID threshold as intensity decreased by 0.5 dB SPL for correct responses and increased by 1 dB SPL for incorrect

responses until the lowest intensity at which the animal achieved 66% correct was obtained. Following baseline testing, chinchillas received a single dose of 75 mg/kg of carboplatin (i.p.). or we exposed to 89 dB octave band noise centered at 4 kHz for 24 hours. All measures were re-assessed after a four-week recovery period.

Results: Following carboplatin treatment there were no significant elevations of ABR or pure tone thresholds and no significant changes to DPOAE; results suggesting that hearing sensitivity remained unchanged. Consistent with previous studies, ABR wave 1 was reduced following IHC loss. Chinchilla IID thresholds, however, were significantly elevated following carboplatin treatment. Following the noise exposure, animals had a temporary threshold shift that recovered at 4 weeks post noise as measured by ABR thresholds and DPOAE amplitudes and a permanent reduction of wave 1 at high frequencies. Histological analysis confirmed cochlear synaptopathy. IID was negatively impacted following synaptopathic noise exposure with greater deficits at the high intensity level.

Conclusions: These results suggest that IHC loss and damage may impact sensitivity to intensity changes and that this model could be used to study the effects of cochlear pathologies involving IHC

COCHLEAR IMPLANTS

Category: Cochlear Implants

Poster #: 135

Categorical Perception of Vocal Emotions with Bimodal Hearing

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Objectives: The ability to recognize vocal emotions is crucial for the success of social interactions and the quality of life. Normal-hearing (NH) listeners perceive vocal emotions categorically, showing a sharp transition from one emotion category to another when identifying continua of emotional stimuli and better discrimination of stimulus pairs across emotion categories than within a category. Cochlear implant (CI) users have poorer vocal emotion recognition scores than NH listeners, due to the limited access to pitch cues with CIs. However, it is unknown whether CI users also show categorical perception of vocal emotions. In fact, their discrimination of emotional stimuli has never been studied. This study tests the impact of bimodal hearing on categorical perception of vocal emotions. The hypothesis is that evidence of categorical perception of vocal emotions may be observed with bimodal hearing but not with electric hearing alone elicited by CI or acoustic hearing alone elicited by hearing aid (HA).

Design: We plan to test 10 NH listeners and 10 bimodal CI users. The happy and sad expressions of a sentence "time to go" produced by a female talker were both normalized to have a 1-s duration and a 65-dB SPL root-mean-square level. Five stimuli, which transitioned from the happy expression to the sad expression and differed by equal changes in pitch contour on a log scale, were created using Praat. Participants identified the emotion conveyed by each stimulus as happy or sad in a two-alternative, forced-choice task. The percentage of happy responses and the average reaction time were recorded for

the 10 repeats of each stimulus. Participants also discriminated between pairs of adjacent stimuli in the continuum using a dual-pair paradigm. In each trial, one pair contained the same stimuli, while the other contained different stimuli. Participants needed to choose the pair containing the same stimuli. The percentage of correct responses and the average reaction time were recorded for the 8 trials of each stimulus pair.

Results: Preliminary data showed that for emotion identification, NH listeners had steep sigmoid functions and their reaction time was longer at the identification category boundary. For emotion discrimination, NH listeners scored 100% correct for all stimulus pairs, and their reaction time was shorter for cross-category pairs than for within-category pairs. For bimodal CI users, their emotion identification functions were steeper with CI+HA than with HA alone, and in turn than with CI alone. Their percent correct scores for emotion discrimination were also better with CI+HA than with CI or HA alone, but showed no consistent peaks across stimulus pairs. Bimodal hearing did not lead to shorter reaction time than CI or HA alone, and the patterns of reaction time across stimuli were variable for both listening tasks of CI users.

Conclusions: The results of the study will reveal how emotions are perceptually organized in CI users, how emotion discrimination is related to identification, and how bimodal hearing may benefit emotion discrimination and identification of CI users. This information is important for the effort to improve vocal emotion recognition with CIs.

Category: Cochlear Implants

Poster #: 136

Quantifying Middle-Ear Impedance in Normal and Cochlear-Implanted Ears

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Objectives: Cochlear implantation risks disturbing the mechanical structure of the middle ear. The cochlear implant electrode array is typically inserted via the middle ear into the round or oval window. An intact middle ear after surgery is essential for (1) clinical measurements of electrically evoked stapedial reflexes/thresholds and (2) preservation of low-frequency acoustic hearing. Wideband acoustic immittance (WAI) measurements may be used to estimate middle-ear input impedance thus providing a means to quantify the mechanical effects of implantation surgery. The present study examined estimates of middle-ear impedance for implanted ears.

Design: WAI measurements from a previous study were made on 28 normal hearing (NH) ears, and 11 ears with a cochlear implant (CI). Three implanted ears with abnormal tympanometry were included. The impedance estimation method utilizes a middle-ear network model to remove the influence of the ear canal on WAI measurements. Estimated middle-ear admittances were compared (1) between the CI & NH groups and (2) between CI ears with normal (8 ears) and abnormal tympanometry (3 ears).

Results: The CI group had reduced middle-ear admittance magnitude between ~0.12 and 1.1 kHz and increased admittance magnitude between ~1.1 to 2.5 kHz. Distinctions were observed between CI subgroups of normal or abnormal tympanometry.

Conclusions: The middle-ear impedance estimation method shows promise in (1) differentiating ears with normal and abnormal tympanometry and (2) quantifying impedance changes after implantation or, perhaps, during the implantation surgical procedure. The low-frequency decrease observed in admittance magnitude for the CI group is likely due to increased stiffness in the tympanic membrane, especially for the CI ears with abnormal tympanometry.

Category: Cochlear Implants

Poster #: 137 **Mentored Student Research Poster Award**

Comparing Physiological and Psychophysical Spread of Excitation: ECAP versus PTCs

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Objectives: Cochlear implants struggle to convey good spectral resolution to listeners, which is important for speech perception. One reason for this is channel interaction: when adjacent electrodes have a broad spread of excitation, they stimulate overlapping neural regions and frequency information is degraded. Spread of excitation can be measured physiologically using electrically evoked compound action potentials and behaviorally using forward-masked psychophysical tuning curves, but it is uncertain whether the behavioral performance is driven by peripheral physiology or by central processing. This study aims to compare the two measures in experienced cochlear implant listeners in preparation for a similar longitudinal study in newly implanted listeners. We hypothesize that spread of excitation measured physiologically and behaviorally will positively correlate.

Design: Spread of excitation from electrically evoked compound action potentials and psychophysical tuning curves were measured at two electrodes in six Advanced Bionics recipients. Every participant had greater than six months of experience using their implant. An improved panoramic electrically evoked compound action potential method was used to account for the individual effects of each masking electrode's spread of excitation as well as the probe's. From this physiological measure, an estimate of current spread can be calculated for the probe electrode. Psychophysical tuning curves were measured using a forward masked, 3-alternative forced choice method with a fixed probe level and adaptive masker level. Linear regression was used to calculate the mean slope, or sharpness, of each tuning curve. These slopes were compared to estimates of current spread using linear mixed effects models to account for repeated measures from individuals.

Results: In this preliminary data, no significant correlation was found between physiological current spread of the probe electrode and mean slopes of psychophysical tuning curves. Further data collection is required to reach statistical power.

Conclusions: The lack of correlation between current spread from electrically evoked compound action potentials and psychophysical tuning curves in this small dataset suggests that behavioral performance is not driven by physiological spread of excitation in experienced cochlear implant listeners. If these results are consistent once more participants have been tested, then it is possible that either central processing contributes heavily to psychophysical tuning curves or that the stimuli used in each method measures different qualities of the auditory periphery. A longitudinal study of these two measurements could clarify whether the two measures initially correlate before diverging due to acclimatization to the cochlear implant. This would contribute to the field's understanding of changes that occur following implant activation.

Category: Cochlear Implants

Poster #: 138

Remote Programming Outcomes with CI Recipients in Chile

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Objectives: Remote programing has the potential to lessen the burden of in-person clinical follow-up borne by CI recipients and their families, as well as CI audiologists. With a CI sound processor's in-built universal Bluetooth capability that allows two way streaming from any Bluetooth audio device, a smartphone with a dedicated app transform into a wireless programming interface. Consequently, the patient can be programmed from anywhere with a stable internet or cellphone data connection. This presents opportunities to improve clinical efficiency of CI follow-up for the patient and the audiologist. The present study evaluates the effectiveness, efficiency and acceptability of such a remote programming system from the perspective of CI recipients and their audiologist. The effect of patient factors (e.g., speech perception scores and tech literacy) and programming environment factors (e.g., data speed and ambient noise levels) are also assessed.

Design: Participants are 15 adults CI recipients attending the Otorhinolaryngology Service of a Hospital located in Santiago-Chile. CI programming is conducted in-person (face to face) as well as remotely via the afore described remote programming system. In both set-ups, the clinician uses the standard programming software and feature set. The order of the in-person and remote programming sessions is randomized. Additional programs are created. Impedances and NRIs are measured.

Results: Data collection is ongoing and specific results will be described in the presentation.

Conclusions: Remote Programming can be successfully leveraged for cochlear implant follow-up. The opportunity to use the patient's smartphone as a programing interface has the potential to reduce the burden of in person visits and optimize the clinical follow-up of CI recipients.

Category: Cochlear Implants

Poster #: 139

Measuring and Modifying Listening-Related Fatigability in Cochlear Implant Users

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Objectives: Listening in noise can be a fatiguing experience for many cochlear implant (CI) users, but research examining why, and how, their fatigue develops is limited. In this study we explore fatigue development in CI users as they complete a cognitively demanding speech task. The impact of task difficulty on fatigue development is also examined by having CI users complete the speech task while listening in a harder (OMNI) and easier (directional; DIR) listening conditions. Fatigue development in CI users is compared to a normal hearing (NH) group.

Design: To date, 10 CI users ($\bar{X}$=50.6 years) and 10 NH ($\bar{X}$=25 years) adults have participated. Data collection is ongoing. Participants complete a 50-minute, demanding, dual-task. The primary task is word recognition (WR) in a fixed (60 dBA) noise. A continuous stream of words is presented from a loudspeaker with noise levels set so single-task scores in noise are ~65% of a participant's quiet score. The secondary task is noun identification response times (RT). Participants repeat each word and press a button as quickly as possible if the word is a noun. Subjective "right now" fatigue ratings are obtained several times during the task. Changes in WR and noun RTs over time provide behavioral evidence of fatigue. Participants also complete the Psychomotor Vigilance Task (PVT), a measure of vigilant attention, before and after the dual-task. Slower post-task PVT RTs suggest increased fatigue. CI users complete these tasks twice, on separate days, listening in OMNI and DIR modes. NH participants are tested only once. Measures of long-term listening-related effort and fatigue are obtained using the Effort Assessment Scale and the Vanderbilt Fatigue Scale, respectively.

Results: All participants had large increases in their "right now" fatigue ratings over time. Although differences between groups and conditions are small, our results show we successfully induced speech-processing related fatigue in a lab setting. Additionally, results show noun RTs are faster for NH compared to CI users and, as expected, WR and noun RTs improved in DIR mode. Behavioral evidence for fatigue, however, is variable. In all cases, post-test PVT RTs are significantly slower, suggesting degraded vigilant attention- a marker of fatigue. However, there were no significant interactions between conditions. Across conditions, WR scores improved over time, consistent with learning effects. In contrast, changes over time in noun RTs varied between groups and conditions. In OMNI mode RTs remained stable over time, while in DIR mode, and for NH, RTs improved- consistent with learning effects. The minimal improvements in OMNI RTs (compared to DIR and for NH listeners) supports the hypothesis that such improvements are reduced by fatigue-related performance decrements in the more difficult (OMNI) listening condition.

Conclusions: Subjective and behavioral measures confirm that sustained listening can be fatiguing for NH and CI users. Preliminary analyses suggest that fatigue growth may be more rapid for CI users compared

to NH listeners and in OMNI vs. DIR modes, although additional data are needed to confirm these findings.

Category: Cochlear Implants

Poster #: 140

The Impact of Cochlear Implant Channel Interaction on Timbre Identification in Pediatric and Adult Users

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Objectives: Despite advances in cochlear implant technology, recipients struggle to process complex sounds in real-world environments, such as speech-in-noise and music. Poor performance results from device artifacts (e.g., adjacent channel interaction, distorted signal input) and age-specific biological differences (e.g., neuronal health, auditory plasticity). The extent to which distorted signal input from neighboring electrode channels contributes to poor outcomes differentially in pediatric and adult users is unclear. Standard practice for programming children is a one-size-fits-all approach based on parameters defined by adult cochlear implant users. However, evidence suggests that pediatric cochlear implant users may be more affected by channel interaction due to a higher capacity for neuroplasticity and greater populations of healthy neurons in children compared to adults. This study seeks to determine age-related differences in unwanted channel interaction and the impact on fine spectral resolution assessed by timbre identification when these interactions are reduced. We hypothesize that pediatric cochlear implant users will demonstrate greater improvement in timbre identification than adults when channels are selectively deactivated.

Design: This was a prospective study involving Advanced Bionics cochlear implant users; Three post-lingually deafened adults (4 ears) and one 11-year-old, early implanted child have been tested so far. Focused stimulation thresholds were obtained for electrodes 2 through 15 using a sweep procedure. The electrodes with the highest thresholds were identified as those likely to have the highest degree of channel interaction. An experimental map was created by deactivating high threshold electrodes while the participant's everyday clinical map served as control. Participants completed the University of Washington Clinical Assessment of Music Perception for Cochlear Implants (CAMP) timbre identification test using their clinical map and the experimental map in a randomized fashion. The timbre test includes the identification of 8 different musical instruments representing the four main instrumental classes. The primary outcome of the study was timbre performance.

Results: Both cohorts improved in timbre identification performance with the deactivated experimental map - however, pediatric users demonstrated greater improvement than adult users (13% vs 6.3%). For both age groups, the greatest benefit was seen with identifying brass and woodwind instruments (peds 21% improvement; adults 19% improvement) as opposed to string and percussive instruments (peds 4.5% improvement; adults -0.76% improvement). Pediatric and adult cochlear implant users performed

worse on identifying brass and woodwind instruments (peds 25% correct; adult 41% correct) than percussive and string instruments (peds 42% correct; adult 52% correct). Brass and woodwind instruments were frequently mistaken for other instruments within the same class (peds 78%; adults 87%).

Conclusions: The pediatric cochlear implant user performed better on timbre identification tasks, particularly those that require fine spectral resolution when channel interaction is reduced via selective deactivation. These preliminary results support our hypothesis that pediatric cochlear implant users may be more sensitive to channel interaction than adult cochlear implant users, but more data will be collected to confirm these findings.

Category: Cochlear Implants

Poster #: 141 **Mentored Student Research Poster Award**

Effects of Audiovisual Speech Training in Adult Cochlear Implant Users

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Objectives: Cochlear implants can restore hearing in many deaf adults, but speech recognition outcomes are highly variable. Speech understanding is a complex phenomenon that involves the integration of auditory and visual speech cues. The temporal binding window (TBW) is a measure of audiovisual temporal acuity, and our lab has previously shown that the size of the TBW can be narrowed through training using a simultaneity judgment (SJ) task. We predict that SJ training will have a comparable effect on cochlear implant users, and that this improvement in audiovisual temporal acuity will result in improvements in speech understanding.

Design: Adults with normal hearing (N=6) or cochlear implants (N=4) participated in a computerized SJ training program over 3 days. TBW size, auditory-only, visual-only, and audiovisual word recognition in noise were evaluated before and after SJ training. We also evaluated changes in cortical activation patterns to auditory, visual, and audiovisual speech using functional near-infrared spectroscopy (fNIRS). To account for learning effects from repeated testing, normal-hearing participants were randomized to receive either SJ training and testing or SJ testing only.

Results: Following training, all participants demonstrated significant improvements in their TBW size (537 ms to 374 ms; p=0.0008). Participants who completed SJ testing-only had no significant changes in TBW size (597 ms to 568 ms; p=0.695). Auditory word recognition in noise also improved following SJ training (19.8% to 26.1%; p=0.058) compared to SJ testing alone (20.8% to 14.4%; p=0.129). Finally, we found that decreases in TBW were significantly correlated with increases in auditory word recognition (p=0.036).

Conclusions: We demonstrate for the first time that the audiovisual temporal acuity of cochlear implant users can be narrowed through SJ training. Improvements in TBW size also led to improvements in auditory word recognition, suggesting that audiovisual training may be an effective intervention for

improving speech understanding in cochlear implant users. In summary, audiovisual integration plays a key role in speech understanding, and improving audiovisual temporal acuity through training enhances auditory word recognition in cochlear implant users.

Category: Cochlear Implants

Poster #: 142

Cochlear Ossification with a Partial CI Insertion and Apical Electrode

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Objectives: A new technique for providing apical stimulation in combination with standard length electrode arrays has been adapted to treat a patient with cochlear ossification preventing a complete electrode insertion. In this technique, the extra-cochlear ground ("ECE1", an independent lead usually placed under the temporalis muscle) is inserted into the cochlear helicotrema via an apical cochleostomy. In this presentation, we will describe the outcomes of a case study to illustrate how the placement of an additional apical electrode may provide benefits for patients where complete electrode array insertions are not possible.

Design: A single-sided deaf (SSD) 8-year-old male patient was referred to our clinic. He had previously been implanted with an electrode array with only 10 out of 22 contacts placed into the cochlea. Ossification of the cochlea prevented the electrode to be inserted more deeply. The patient was unable to understand speech through the cochlear implant alone.The patient was reimplanted at NYU. A similar insertion was achieved with only 10 out of 22 electrode contacts inside the cochlea. However, the additional electrode, ECE1, was implanted successfully into the cochlear helicotrema. In the clinical fitting software, up to 22 channels can be provided, with each stimulating a corresponding electrode in a typical configuration. However, the clinical system allows each frequency channel to stimulate in reference to either an electrode on the case ("MP2") providing monopolar stimulation or with reference to the apically placed electrode ("MP1"). With this patient, we have tried multiple stimulus and frequency allocation configurations to determine optimal outcomes.At activation post reimplantation, the patient was sent home with two different maps. One map was a conventional map stimulating on all intracochlear electrodes on the array in monopolar mode and not using the apical electrode. The other map had an additional channel in which the lowest frequencies were presented on the most apical electrode on the electrode array with reference to the electrode in the helicotrema. At the second mapping visit, the patient reported a preference for the map including the helicotrema reference electrode. Again, he was sent home with his preferred apical map as well as a novel map using the apical electrode to increase the number of channels. At the third mapping visit, the frequency allocation of each of the maps was optimized to improve tonotopic representation.

Results: With the apical configuration, the patient had CI-only closed-set speech recognition and indications of emerging open-set speech recognition, which was not possible prior to the apical electrode placement. The patient consistently prefers the maps that include the apical electrode. Furthermore,

pitch ranking suggests that even with an ossified cochlea, grounding to apex (MP1) produces a lower pitch than grounding to case (MP2).

Conclusions: Placement of an additional electrode in the cochlear helicotrema is a potentially effective treatment when ossification prevents complete insertion of an electrode array. Unlike with a split or double electrode array (neither of which are presently on the market), the decision to place ECE1 in the cochlear apex can be done after experiencing trouble achieving a full insertion with a full-length electrode without completely replacing the implant.

Category: Cochlear Implants

Poster #: 143

Using an App to Measure Cochlear Implant Impedances in Everyday Life

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Objectives: Cochlear implant fittings are optimized based on performance and subjective evaluations of recipients as well as measures of device function such as electrode impedance. Impedances are typically measured during in-person clinic visits which can be separated by months to years. Programming actions undertaken based on these impedance measurements are assumed to be relevant for everyday listening in-between clinic visits. However, impedances fluctuate day-to-day, for example due to illness, fluctuations of hormones, or inflammatory responses. If there is a considerable increase in electrode impedances, the implant may no longer be able to provide high enough voltage to deliver required stimulation levels. This could impact sound perception including overall loudness, speech perception, and sound quality.

Design: At the time of abstract preparation, we had recruited 47 participants (31 had completed the study) aged 8 - 79. Participants were asked to measure impedances through AB's research app at least once a day for three months. App notifications were enabled to allow daily reminders at the time selected for each participant. Study compliance was monitored on a weekly basis and participants who missed measurements were sent a reminder to make the daily measurements.

Results: Preliminary results show that the majority of participants were able to complete the impedance measurements in a timely manner without much involvement from the researchers. Thirteen of the 31 participants who had completed the study missed fewer than 15% of measurements over the course of the study. Preliminary analyses show that while large impedance fluctuations are rare, impedances do

fluctuate from day-to-day. 91% of impedances fluctuated less than +/- 0.5 kOhm around the mean (range of impedance deviations from the mean: -6.7 to 7.1 kOhm). The occurrence of any impedance fluctuations that exceed compliance voltage limits, which could have the potential to affect hearing performance, will also be discussed.

Conclusions: This study shows that an app-based data collection tool can be used to make objective measurements such as electrode impedances outside the clinic environment without direct clinician or researcher oversight. Collection of remote impedance data could be further improved by automating measurements. From a research perspective, remote data collection can ultimately afford enrollment of large participant populations for any given study. From a clinical perspective, the ability to monitor impedances remotely opens the door to uncover optimization opportunities to CI program parameters between clinic visits.

Category: Cochlear Implants

Poster #: 144

Differential Assessment of Musical Timbres by Unilateral Cochlear Implant Recipients

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Objectives: The question addressed by this research was focussed on differences in timbral character of musical instrument tones as perceived by each experimental participant via their normal-hearing ear versus their unilateral cochlear implant (CI). The question was whether audio signal processing that simulates CI-based effects on timbre could reduce the perceived dissimilarities in musical instrument timbre associated with normal-hearing and listening via CI. The hypothesis to be tested can be stated as follows: The perceptual magnitude of differences in timbre introduced by unilateral cochlear implant use will be rendered small relative to within-ear timbral differences between presented musical instrument tones, as an indication of the success of the CI simulation under test.

Design: The three tested subjects were unilateral cochlear implant recipients with post-lingually acquired single-sided deafness. Each subject could perceive sound "electrically" and "acoustically," respectively, via their cochlear implants and via their normal-hearing ears; therefore, successive monotic stimulus presentations afforded an opportunity to investigate the associated perceptual differences in timbre within each single subject. A within-subject experimental design was implemented in which dissimilarity judgments were collected for music instrument tones presented pairwise for two types of pairwise comparisons, either within-ear comparisons or between-ear comparisons. A set of pitch- and loudness-matched musical instrument tones was designed to reveal the perceptual magnitude of timbral differences between the tones with reference to a common psychological scale that was shared for within-ear and between-ear comparisons made by unilateral cochlear implant (CI) users. The set of original-version tones comprised the original recordings of six orchestral instruments, including oboe, clarinet, bassoon, French horn, trumpet, and trombone. All of these tones were performed with a fundamental frequency of 261.6 Hz (middle C); however, the set of 'transformed-version' tones comprised spectrally transformed copies of the original recordings with fundamental frequency shifted

up by two octaves to 784.8 Hz. For each listener, this pitch shift resulted in an approximate pitch match at the non-implanted ear to the pitch of the original tones as perceived via CI.

Results: For a set of pitch- and loudness-matched musical instrument tones, the differential assessment of musical timbres by unilateral cochlear implant recipients revealed the perceptual magnitude of timbral differences between the tones with reference to a common psychological scale that was shared for within-ear and between-ear comparisons made by unilateral cochlear implant (CI) users. The resulting differences were quantified using Individual Differences Scaling (INDSCAL) analysis, which enabled the derivation of both a Stimulus Space and a Subject Space from the obtained pairwise dissimilarity judgments. A common two-dimensional Stimulus Space (aka 'timbre space') was derived that revealed the relative positions of the members of the two sets of tones for two types of comparisons, which were either a within-ear comparison or a between-ear comparison. The derived Subject Space provided a quantitative assessment of the weights placed upon each of the two timbral dimensions of the Stimulus Space in the cases of within-ear versus between-ear comparisons.

Conclusions: The resulting quantitative assessment of audible differences between musical instrument timbres revealed the timbral dimension that was more substantially affected by CI use. It was concluded that such within-subject studies employing unilateral CI recipients can play a special role in understanding of timbre perception, understanding which could inform improved CI audio signal processing and potential rehabilitation programs for future CI recipients.

Category: Cochlear Implants

Poster #: 145

Pilot Study: Speech Perception Outcomes with Experimental Cochlear Implant Programs

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Objectives: There is vast variability in listening performance in cochlear implant (CI) users. Prior work has illustrated that much of this variability in adult CI users can be captured with peripheral estimates of the quality of the electrode-neuron interface (ENI). Estimates are taken by measuring detection thresholds with focused electrical fields and measuring channel interaction with electrophysiological and psychophysical tuning curves. Programming can be tailored to individuals with selective channel deactivation of the highest threshold channels and use of focused electrical fields for relatively high threshold channels, thus reducing channel interaction. After completing these ENI estimates, experimental programming strategies are designed to maximize speech recognition for CI listeners. Two experimental processing strategies were programmed and evaluated for each of the four subjects based on ENI measures. The two strategies were evaluated over two, five-week periods during which time subjects wore an Advanced Bionics Harmony research processor for everyday listening and completed speech perception testing once a week at home on lab-provided tablet. We hypothesized that listeners

would improve with the optimized programs over this time. We predicted the focused optimized program would outperform the monopolar (MP) program. Our objectives were to (1) quantify longitudinal changes in speech perception performance and (2) use the pilot data to evaluate our study methods.

Design: Participants were recruited from the Mass Eye and Ear Audiology clinic. Four participants completed this pilot study to date. Thresholds were obtained for all electrode channels using a fast, sweep procedure and a highly focused electrical field. Dynamic tripolar (DT) stimulation focuses current proportionate to input such that low-level sounds are focused at σ 0.8 and high-level sounds are focused at σ 0.5 reducing channel interaction and increasing spatial selectivity. For two participants, comparisons are between an MP, all channel control, and a DT program with high threshold channels deactivated (A013, A015). One participant used an MP all channel control compared to an MP program with high threshold channels deactivated. The final participant used their clinical processor as a control (comparable to the MP all channels used by the other three participants) compared to a mixed focused program where the highest threshold channels were deactivated, low threshold channels were programmed in MP and remaining channels were programmed in DT. Speech perception testing included vowel identification in the h/|v|/d context and IEEE Sentences. Testing was completed in quiet and in noise with varying signal-to-noise ratios (SNRs) to assess a range of performance. Testing was completed at baseline in the lab. Subjects used the strategies regularly and weekly speech testing was completed at home.

Results: Data suggests that subjects generally showed slight improvements in performance when using the optimized strategies and this improvement was greater for sentences in noise than vowels. Improvements varied across SNRs for the optimized strategy.

Conclusions: While results are preliminary, the data suggests listener-tailored strategies may improve speech perception outcomes when provided time to acclimatize. This pilot study demonstrates a need for further testing with a larger study population.

Category: Cochlear Implants

Poster #: 146

Can Electrocochleography Predict Electroacoustic Benefit?

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Objectives: When a cochlear implant (CI) recipient uses residual, amplifiable hearing (<80dB HL) in the CI ear with a hearing aid (HA) it is called Electroacoustic stimulation (EAS). EAS can potentially be used in one ear or both ears, and measuring benefit can be done by taking the difference between the best-aided score in the EAS condition versus the bimodal condition without a HA component in the CI ear. Often EAS benefit does not reveal itself on standard clinical speech tests but can be shown on tests in complex listening environments such as non-collocated speech in noise. Assessing performance in more complex listening scenarios, most exhibit EAS benefit, but not all demonstrate EAS benefit. Further complicating

this space, fitting of the EAS component takes clinical time, and since benefit can be cumbersome to test, there is no easy way to quantify outcomes or predict who may receive benefit from a clinical perspective. Electrocochleography (ECochg) is an evoked potential that can be used to assess the ability of the cochlea to encode an incoming acoustic signal. Recent technological advances have made it possible to record ECochg directly from the CI electrode array. The sum of responses across the frequency spectrum (500, 1000, 2000, and 4000Hz) can be transformed into a measure called Total Response (TR). The purpose of this study is to use the TR measured through the CI in established CI users as an objective measure to predict EAS benefit. Because the TR is a measure of the cochlea's ability to encode an incoming signal, it is hypothesized that TR will show a positive relationship to EAS benefit.

Design: 13 Cochlear brand recipients who are eligible to use EAS will be tested using the Cochlear Research Platform 1.2. The TR will be extracted from the ECochg recorded through the CI. Participants will also be tested on Interaural Timing Difference Thresholds (ITDs) using a 2-down, 1-up adaptive procedure at 250Hz and the Binaural Intelligibility Level Difference (BILD) test. The BILD test presents adaptively varying spondees in fixed-level noise with the noise in-phase and out-of-phase across ears. The BILD is equal to the difference between the in-phase condition and the out-of-phase condition. AzBio sentences in R-SPACE single-talker babble noise S0N45-315 and an asymmetric two-talker babble (S0N45&270) noise test using BEL sentences will be used to assess EAS benefit.

Results: Pilot data collected on two current EAS users revealed a TR of 12.6dB and 11.4dB. ITD thresholds for 250Hz were 550us and 380us, and BILDs were 7.17dB and -5.33dB, respectively. To date, EAS benefit has been measured for the first participant showing a 12.5 percentage point increase in R-SPACE single-talker babble noise S0N45-315.

Conclusions: Both EAS users have similar TRs and useable ITDs. ITDs have been shown to correlate with EAS benefit but are not clinically feasible. The BILD, which represents a higher level of auditory processing reliant on high and low frequency information, shows a different effect related to EAS benefit. Since the TR follows the same pattern as the ITD, this suggests that TR may provide an objective measure that reflects useable periodicity in neural firing which is critical for ITD sensitivity and thus, may help predict EAS benefit.

Category: Cochlear Implants

Poster #: 147

CI Signal Enhancing Parameters and Strategies Selection and Speech Recognition

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Objectives: The objective of this study was to evaluate the effect of adjusting the following settings on soft speech recognition and speech recognition in noise: (1) input dynamic range (IDR), (2) threshold levels

(T-level; 10% vs measured), (3) soft speech enhancement (SSE), (4) adaptive noise reduction (ANR), and, (5) an automatic scene classifier (ASC).

Design: A within subjects, repeated measures design was used. Twenty-one CI recipients (age range 16 to 79 years), with at least 6 months of CI use and a CNC score of >60% participated. Soft speech recognition (CNCs at 45 dBA) was evaluated as a function of IDR (40, 60, and 80 dB), T-levels (10% of most comfortable levels (default) vs. measured) and SSE (on vs. off). Sentence recognition in noise (AzBio sentences in diffused classroom noise at an individualized signal-to-noise ratio (SNR)) was evaluated as a function of IDR (40, 60, and 80 dB), ASC (on vs off) and ANR (medium vs off).

Results: At a group level, there was a significant benefit of activating SSE on soft speech recognition in quiet at 40 dB IDR with measured T-levels (p=0.005) and at 60 dB IDR with T-levels set to default (p=0.005). Soft speech recognition was also better with measured Ts than T-levels set to default at 40 dB IDR with SSE enabled (p=0.003). While not statistically significant, the highest performance for speech understanding in noise was observed at 60 dB IDR with ASC and ANR enabled. Marked individual variability was observed and will be discussed.

Conclusions: Based on the study results, use of T levels set to 10% of most comfortable levels (default), with IDR set to 60 dB and ASC, ANR, and SSE enabled can serve as a starting point for CI recipients upon activation with consideration for adaptation based on individual needs long-term.

Category: Cochlear Implants

Poster #: 148

Accuracy of Estimated Electrode Insertion Angle Using X-rays

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Objectives: Computed Tomography (CT) Scans are an excellent modality for estimating electrode location of cochlear implants. X-rays, which use less radiation than CT scans, have been used when CT scans are not available or feasible. The goal of this study is to investigate the accuracy of X-ray estimations of cochlear implant angle of insertion for the most apical electrode, compared to gold-standard estimates obtained from CT-scan reconstructions.

Design: For six cochlear implant patients, we measured the insertion angle of the most apical electrode using both X-rays and CT scans. X-ray measurements were completed by several otologists and cochlear implant researchers with different levels of experience ranging from novice to experienced. We compared results obtained with X-rays and with CT scans and reviewed potential sources of error in measuring electrode insertion depth using x-rays.

Results: Estimated apical electrode insertion angles were shallower when using X-rays, compared to when CT reconstructions were used. After correcting for these systematic differences, there were still some random differences between X-ray and CT estimations (about 15-20 degrees). Potential sources of error when measuring apical insertion depth using a cochlear implant x-ray fall within 3 categories: estimation of the location of the most apical electrode, the location of the center of the cochlear spiral, and the reference point (which is often the location of the round window). We discuss each one of these sources of error. Results also include a visual comparison of cochlear implants using X-rays and CT scans.

Conclusions: X-ray can be used to measure the angle of insertion of the most apical electrode of cochlear implants, but there are both systematic and random differences when compared to results obtained from CT scans.

Category: Cochlear Implants

Poster #: 149

Towards Bilateral Cochlear Implant Programming: Asymmetric Sensitivity to Electrical Stimulation

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Objectives: The study aim was to investigate how the programming of stimulation parameters in bilateral cochlear implant (CI) users differs between bilateral pairs of electrodes. Interaural differences in sound intensity are essential for spatial hearing and hearing in noise but asymmetries in CI stimulation levels may obscure these binaural cues. Asymmetries can occur due to device differences (perimodiolar arrays positioned proximal to the modiolus compared to antimodiolar arrays located near the lateral wall) or inter-implant delay (simultaneous versus sequential procedures). The hypothesis tested was that longer inter-implant delays have a greater impact on the balance of bilateral input than array type mismatches.

Design: CI stimulation parameters reported in charge per phase in dB (T-levels, C-levels, and the dynamic range (DR) between T- and C-levels), thresholds of electrically evoked compound action potentials (ECAPs), and other relevant clinical information were gathered retrospectively (September, 2003 and July, 2022). Children bilaterally implanted (n = 622 children) who had not undergone explanation with data available for both devices measured within a one-year span were included (n = 443 sequentially implanted, n = 179 simultaneously implanted, n = 536 with matched perimodiolar arrays, n = 86 with one perimodiolar and one antimodiolar array). A mixed effects modeling analysis was conducted. Estimated marginal means(SE) are reported.

Results: The DR did not differ between array types whereas ECAP thresholds, T- and C-levels were lower for perimodiolar arrays than antimodiolar arrays ($p< 0.001$). All measures were significantly greater for the first implanted ear than second implant ear for sequential CI users (ECAP thresholds, T-levels, C-levels, DR: $p<0.01$). Absolute differences in T- and C-levels and the DR revealed a greater disparity between the two CIs in the sequentially implanted than simultaneously implanted groups (C-levels: mean(SE) = -1.04(0.32) in dB, $p< 0.01$; T-levels: mean(SE) = -0.70(0.26) in dB, $p< 0.01$; DR: mean(SE) = -1.74(0.20) in dB, $p<0.0001$), but not ECAP thresholds ($p = 0.41$). T-levels were significantly lower for children with matched perimodiolar arrays than children with one perimodiolar and one antimodiolar array (T-levels: mean(SE) = -0.46(0.18) in dB, $p< 0.01$) with no significant differences in the ECAP thresholds, DR and C-levels between children with matched perimodiolar arrays and mismatched array types.

Conclusions: Bilateral differences in the DR, C-levels and T-levels are more attributable to implantation sequence than array type. The observation of absolute bilateral differences in MAP stimulation levels but not ECAP thresholds suggests programming may be based more on behavioral responses to stimulation levels that can be affected by hearing experience rather than the electrode-neural interface on each side.

Category: Cochlear Implants

Poster #: 150

Novel Measures for Assessing Auditory Nerve Health in Cochlear Implant Recipients

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Objectives: Cochlear implant (CI) performance is related, at least in part, to the health of the auditory nerve in adult recipients. Previous studies in humans, based on metrics derived in the animal model, show evidence that speech recognition outcomes are related to the number of surviving spiral ganglion neurons (SGNs) that directly interface with the electrode array. The interaction between neural health, aging and speech recognition is unclear, although several studies point to poorer understanding of complex speech in older CI recipients. In normal hearing listeners, temporal properties of the auditory nerve help to predict complex speech understanding in aging adults. The primary objective of the study is to further develop and design novel metrics of auditory nerve temporal coding in CI users to better understand the relationship between speech recognition in aging.

Design: The study included 44 postlingually-deafened adult CI recipients (ages 39-88) with Cochlear™ implant systems. Participants were selected from the medical centers' clinical population or nearby clinics. All participants reported English as their first language. Measures included metrics of the electrically-evoked compound action potential (ECAP), computerized tomography to evaluate electrode location, and sentence recognition in noise performance.

Results: Results showed that aging was associated with poorer speech understanding in noise. ECAP amplitude (which predicts SGN density in the animal model) is not related to speech understanding in noise. However, ECAP metrics which are thought to reflect dyssynchrony of the AN were related to age. Specifically, greater AN dyssynchrony was observed in older CI recipients.

Conclusions: Here, we provide preliminary evidence that age-related changes to speech-in-noise recognition in CI users arerelated to AN dyssynchrony using an ECAP metric that is simple to assess and is relatively independent of other confounding factors. Further work will examine and compare these results with other features of AN health to include disengagement and biodiversity, to help better explain variance in speech recognition with cochlear implants

Category: Cochlear Implants

Poster #: 151

Clinical and Statistical Predictions of Speech Outcomes after Cochlear Implantation

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Objectives: A clinically meaningful improvement in speech perception is generally considered the key benefit of cochlear implantation (CI), and is frequently used to evaluate CI success. While speech perception test scores tend to increase in most adult postlingual CI users compared to their pre-CI baseline, individual improvement is highly variable. In most statistical models, only a small portion of the variance (typically less than a third) can be accounted for by patients' general demographic and hearing loss-specific factors. On the other hand, little is known about the ability of hearing healthcare professionals who advise CI candidates to predict post-CI speech perception outcomes for individual

patients. The goal of the present study was two-fold: (1) to evaluate the accuracy and variability of clinical predictions of post-CI speech perception outcomes for individual patients based on information typically available prior to implantation, (2) to directly compare accuracy and consistency of clinical and statistical predictions in order to develop an optimal approach for speech outcome prognostication.

Design: An online survey study was conducted with participation from CI surgeons, audiologists, speech-language pathologists, and researchers. The survey participants predicted the 6-month performance on AzBio sentences in quiet and in noise and CNC word recognition in quiet for 15 anonymized CI patients. Each case presented patient demographic, medical, and audiological data, along with preoperative speech recognition scores. Prediction confidence, demographic and professional background information was also collected from all participants.

Results: Seventy-two participants provided predictions for at least one case, and 43 provided predictions for all 15 CI cases. The median familiarity of participants with AzBio and CNC tests was 100%. Most participants (85%) were audiologists with multiple years of experience in CI care. However, clinical predictions for individual CI cases had low accuracy and high variability. Specifically, measures of consistency and agreement of the predicted and actual scores, i.e. interclass correlation (ICC) coefficients, had low median values (0.12 to 0.18 in the 0 to 1 possible range). Furthermore, approximately two-thirds of individual predictions differed from the true patient scores by more than 10 points. In contrast, predictions from a linear regression model, which accounted for up to 33% of the variance, showed somewhat higher accuracy and consistency for AzBio in quiet and CNC: ICC of 0.41 and 0.52, respectively. No relationship was observed between clinicians' confidence or their background and prediction accuracy.

Conclusions: The present findings indicate a concerning discrepancy between clinical predictions and actual speech perception outcomes for adult post-lingual CI users. Predictions from a statistical model, although also suboptimal, had greater accuracy. To the extent that anticipated speech perception benefits can influence clinical guidance and patient expectations, improving accuracy and reducing variability in outcome expectations should enhance patient satisfaction and post-CI care management. Future research may explore combining human predictions with approaches based on statistical modeling to improve counseling for individual CI candidates.

Category: Cochlear Implants

Poster #: 152

Orthographic Transcriptions Enhance Accent Identification in Cochlear Implant Users

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Objectives: Everyday speech communication involves interacting with unfamiliar talkers with diverse voices and accents. Adult cochlear implant (CI) users are less sensitive to accent variability in speech relative to their normal-hearing (NH) peers, which may contribute their substantial difficulty in

understanding speech produced by nonnative talkers. Previous research suggests that top-down linguistic knowledge can be used enhance the perception of accented speech in NH listeners, resulting in more accurate identification of native and nonnative speech. However, the extent to which top-down mechanisms may be effectively used by CI users to enhance accent identification is unknown. The current study investigated whether orthographic transcriptions of a target sentence enhance adult CI users' ability to make accent identification judgements for native and nonnative talkers. Additionally, the study examined the association between accent identification and word recognition across individual CI users, to shed light on the relationship between accent perception and speech recognition outcomes.

Design: Thirty-one post- or peri-lingually deafened adult CI users participated. In an accent identification task, CI users judged whether an utterance was produced by a native or nonnative talker, and provided a rating as to how confident they were about their judgement using a sliding scale (0 to 100). Materials consisted of unique sentences produced either by a native or nonnative talker (with different native languages), with or without a visual, orthographic transcription of the auditorily-presented sentence. The same talkers were presented in both auditory-only and auditory-visual conditions. Participants also completed a multiple-talker word recognition task in quiet. Within the CI group, accuracy and confidence ratings for foreign accent judgements were compared in the auditory-only and auditory-visual conditions. Across CI users, foreign accent identification accuracy and confidence ratings were also compared to word recognition accuracy and verbal response time.

Results: Adult CI users were significantly more accurate at identifying whether sentences were produced by a native or nonnative talker when orthographic transcriptions were available in the auditory-visual condition (M=91%; SD=8%) compared to the auditory-only condition (M=78%; SD=12%). Similarly, they were significantly more confident in their responses in the auditory-visual condition (M=83; SD=14) compared to the auditory-only condition (M=76; SD=19). Across CI users, individual CI users with more accurate and more confident foreign accent identification in the auditory-only condition also showed more accurate and faster word recognition (r's=.47-.65).

Conclusions: Although accent perception may be relatively challenging for adult CI users, visual, orthographic transcriptions of sentences enhance the perception of accent information in speech. Consistent with previous research in NH listeners, these findings suggest that top-down linguistic information may be used to compensate for degraded speech variability information conveyed by CIs to make accent judgements. Results further showed that the ability to make accent identification judgements based on auditory information alone is closely tied to speech recognition in adult CI users, also suggesting a common source of difficulty in the encoding and processing of acoustic-phonetic details in speech. Future studies are needed to further understand the implications and potential interventions for poor accent perception in real-world speech communication for adult CI users.

Category: Cochlear Implants

Poster #: 153

Patient's Perceptions via the SSQ Survey Post AR Therapy in CI Adults

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Objectives: Hearing loss in adults may be defined by degrees of loss such as mild, moderate, severe, or profound, but the hearing loss impacts auditory and language comprehension, social and emotional well-being, and multiple aspects of the quality of life for the person. This research presentation aims to examine self-reported improvements from a survey in auditory skills in adult patients pre and post Aural Rehabilitation therapy.

Design: The design of this study is quantitative clinical research with post-lingual cochlear adult implant users. The survey used in this research study is the Speech, Spatial and Qualities of Hearing Scale (SSQ), and all the participants are adults over the age of 60 with at least one cochlear implant. This presentation will review 15 patients and their perception of their own hearing reflected in a self-reported survey in which treatment plans were developed to optimize person-centered functional goals for patients in Aural Rehabilitation.

Results: The SSQ pre-therapy results will be examined to demonstrate how meaningful auditory-specific activities were designed in each patient's AR therapy sessions. In addition, post-therapy improvement ratings will be shared by all patients in the three categories of speech hearing, spatial hearing, and qualities of hearing from the SSQ. This casual-comparative research study will examine how lifestyle factors, duration of deafness, and Aided WRS contributed to subjective measures of success on the SSQ.

Conclusions: For adults with cochlear implants, having the ability to hear through their cochlear implant device does not always translate to being able to understand speech immediately. This study aims to understand better the relationship between scores on traditional audiometric tests and the patient's perception of their auditory skills. This study will show improvements that patients made not only in AR therapy sessions but also in their communication in their daily activities. Results and clinical implications of social participation, language comprehension, and quality of life in adults post-cochlear implantation will be discussed.

Category: Cochlear Implants

Poster #: 154

Discrimination of Intact vs Ambiguated Spectral Cues in CI-Simulated Speech

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Objectives: Cochlear implant (CI) speech-recognition outcomes are influenced by various combinations of bottom-up and top-down factors. As such, there is substantial individual variability in CI outcomes. Assessment tools that go beyond traditional speech-recognition measures are required in order to characterize individual differences in the relative impact of top-down vs bottom-up influences on CI outcomes. The purpose of this project is to assess elliptical speech as a tool for evaluating bottom-up perceptual acuity in CI users.

Design: Noise-vocoded sentence stimuli were presented to 10 normal-hearing (NH) listeners. Stimuli consisted of IEEE sentences that either maintained correct consonant place-of-articulation cues (Intact Speech) or contained consonant "ellipses" that ambiguated spectral cues to consonant place (Elliptical

Speech). The "ellipses" replaced each key-word consonant with a new consonant maintaining the same manner and voicing of the original, but with an altered place feature. Detection of ellipses was evaluated using a same-different discrimination task in which listeners heard a pair of same-word sentences and were asked to categorize each pair as Same (word-for-word, sound-for-sound identical) or Different (word-for-word identical, sound-for-sound different). Four sentence-pair conditions were tested: II, intact-intact, EE, elliptical-elliptical, IE, intact-elliptical, and EI, elliptical-intact. The discrimination task was repeated for different vocoding conditions that varied the number of spectral channels (N = 4, 8, and 16) in order to simulate different levels of bottom-up signal degradation (e.g., good vs poor bottom-up input quality). A concurrent neuroimaging measurement was conducted to estimate cortical activity in bilateral auditory cortex and dorsolateral prefrontal cortex via functional near-infrared spectroscopy (fNIRS). This project tested our hypotheses that: 1) NH participants will successfully detect ellipses in more favorable listening conditions but will be unable to detect ellipses under more degraded listening conditions, and 2) listeners will demonstrate differences in cortical activity in response to Intact vs Elliptical speech depending on the severity of the signal degradation.

Results: Preliminary results for the behavioral discrimination task demonstrated higher accuracy for detecting ellipses with increasing the number of spectral channels in the vocoded stimuli. On average, discrimination accuracy was near chance for the 4-channel condition, whereas listeners could discriminate between Intact vs Elliptical sentences with 75% accuracy for the 8-channel condition. The neuroimaging results revealed that cortical activity was comparable in response to Intact vs Elliptical speech under the highly degraded listening condition. For the more favorable listening condition in which the ellipses were perceptually detectable, differences in cortical activity were apparent, with stronger activity in left auditory cortex and dorsolateral prefrontal cortex for the IE and EI conditions compared to the II and EE conditions.

Conclusions: Preliminary results demonstrate that the detection of ellipses in speech is impacted by the spectral resolution of the signal, and this result is also reflected in listeners' cortical activity. This result has important implications for CI listeners, suggesting that listeners with "good" bottom-up input would be able to reliably discriminate between Intact vs Elliptical speech, whereas listeners with "poor" bottom-up input may not be able to detect ellipses. Elliptical speech is a potential tool for isolating the quality of the bottom-up input from top-down processing of speech.

Category: Cochlear Implants

Poster #: 155

Tracking Listening Effort Timing and Efficiency Rather than Effort Magnitude

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Objectives: Listening effort cannot be adequately described as simply more or less, because highly effortful activities can be very satisfying, and lack of effort might indicate defeat rather than ease. This study embraces the importance of effort efficiency in order to track whether listeners apply their effort in effective ways and withdraw effort when it is not needed. Particular focus was placed on giving opportunity to engage or disengage mental resources at strategic times, which we hypothesize to be an important signature of a person's ability to guard against wasted effort.

Design: Stimuli were designed to create the situation of seeking clarification of a misperceived word or missing information (which would ideally evoke effort aimed only at the clarifying word) or conversely to ignore words that were already heard (which would ideally elicit reduced effort). The task was listening to a sentence that occasionally lacked crucial information, and then giving a follow-up sentence to clarify that exact information. Pupillometry was used as an index of moment-to-moment changes in listening effort as the listener sought that clarifying information. Participants included 36 adults with typical hearing and 17 adults with cochlear implants.

Results: Physically identical stimuli elicited patterns of pupil dilation whose timing reflected specific needs set up by the preceding context, conclusively demonstrating precise effort strategy. Pupil dilations from listeners with typical hearing were linked in time with critical target words (confirming precise measurements of the efficiency of targeted effort), and dilation was reduced at times when the same information was repeated (confirming reduction of effort specifically when it was not needed). Generalized additive mixed models confirm the distinct timing of pupil dilations aimed at different timing landmarks in a sentence based on the listener's needs. However, listeners who wear cochlear implants generally did not display these efficient effort characteristics, instead showing signatures of effort that spread through the entire stimulus regardless of where the crucial information was timed in the stimulus. Additionally, CI listeners were more likely to make mistakes on sentences following those with a misperception, implying a lingering timecourse of effort that can only be revealed in this two-utterance design.

Conclusions: The timing and efficiency of effort need to be examined as a possible source of the difficulties of understanding speech with a cochlear implant. Perhaps a better framework than more/less effort is the extent to which a listener can aim effort and attention at strategic times when listening to speech. Learning about this type of effort requires task designs that allow differing strategies to overcome uncertainty or to strategically withhold effort, and also require stimuli that would reveal the extent of effort over several seconds past the end of the target sentence.

DIAGNOSTIC AUDIOLOGY / OTOLOGY

Category: Diagnostic Audiology / Otology

Poster #: 156

Does COVID-19 Excaerbate Pre-Existing Hearing Loss

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Objectives: This study aimed to determine if COVID-19 considerably affects patients with pre-existing hearing loss. As this was an exploratory study, a definitive hypothesis was not established; however, the principal researcher's theory was that COVID-19 would exacerbate hearing loss in patients with pre-diagnosed loss.

Design: The participants in this study were between the ages of 50 and 64 who had been diagnosed with hearing loss between March 15, 2019, and March 15, 2020, and contracted COVID-19 within six months

of March 15, 2020. The participant's hearing was tested to monitor the regression of hearing loss following a diagnosis of COVID-19. This included the 92557 Medicare billing code tests: air and bone conduction, speech reception thresholds (SRTs), and word discrimination scores (WRSs). Participants had to have tangible documentation of their diagnosis of COVID-19 in the allotted timeframe and quarantine orders.

Results: Using a paired T-test to compare puretone averages (PTAs) of 500Hz, 1000Hz, and 2000Hz, the data suggested that participants' PTAs worsened after the contraction of COVID-19 in both the right and left ears (p-value =<.01). Word recognition scores (WRSs), however, did not decrease when a paired T-test was performed. The researcher used a two-way ANOVA test to evaluate if gender affected PTAs and suggested that gender did not affect the PTAs substantially. Since PTAs did show a clinically significant decrease, it was anticipated that speech reception thresholds (SRTs) would also have worsened, and a paired T-test signified that the SRTs did regress.

Conclusions: While the study's main objective was to establish a viable framework for more longitudinal studies associated with COVID-19, this study also aimed to provide clinicians (PCPs, AuDs, and ENTs) with further evidence of how COVID-19 can affect peripheral hearing sensitivity. By understanding how viral infections disrupt the auditory system, audiologists and physicians can better serve patients with hearing impairments and provide a better pathway to audiological or medical interventions.

Category: Diagnostic Audiology / Otology

Poster #: 157

Hearing Data Collection in India Longitudinal Study of Aging

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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 LASI-DAD Wave 2 was to carry out the quality control and quality assurance plan of pure-tone audiometry within the LASI-DAD field-assessment protocol established in the pilot phase. Prevalence of hearing loss in India was estimated thus far. Considerable obstacles include equipment shipments between hearX (South Africa) and LASI-DAD (India) including India customs processes.

Design: 25 hearX HearTest smartphone-based portable audiometers were procured and dispersed within 18 Indian states. Quality assurance actions included creation of a picture-based, language appropriate Manual of Operations with full instruction scripts and a training plan. One in-person training was held for Wave 2 to give didactic information and motivate approximately 40 field interviewers with importance of assessment, a hands-on walk through of protocol, live feedback on practice assessments, certification to perform assessments, and time for questions. In addition, an on-demand professional video detailing the assessment protocol was created to support field interviewers. Hearing thresholds for five frequencies most important for speech were obtained in both ears (500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz). Quality control included monitoring data in real time using an algorithm that assessed quality of results based on ambient noise present during testing. After data was collected, we assessed the quality by identifying "pink" flags including between-frequency difference >30 dB, difference in pure-tone average ≥ 30 dB, any difference between ears at each frequency ,≥ 25 dB, any noise levels above ANSI levels during testing, and test duration longer than 10 mins (initial duration flagged was 12 mins) or shorter than 2 mins. The second pass leveraged our clinical expertise as our team reviewed device data in the cloud for false responses, generated audiograms for flagged participants, and two clinicians reviewed audiograms for 'plausibility'. The above algorithm was iteratively developed and based on initial pilot as well as the initial 100-200 participants.

Results: LASI-DAD Wave 2 has hearing data for 86.5% of study participants. Hearing testing is not completed on participants with turbans unless they remove them. Hearing assessment duration declined from ~11 to ~5 minutes over the first 6 months of training and data collection. Following 1654 assessments, 40% were flagged for review by qualified audiologists and only 19 were rejected as invalid results. Prevalence estimates of Indians with hearing loss thus far are 74.3% of adults ≥71 years and 86.7% of >85 years.

Conclusions: These represent continuing efforts to incorporate hearing into the first-in-kind LASI-DAD cohort. Over the past year, hearing metrics have been and continue to be collected on the 3000+ participants - yielding the largest nationally-representative, pure-tone audiometry dataset among older Indians. These data show the importance of measuring hearing in rural and urban areas of India. Further, hearing loss prevalence globally informs researchers, clinicians, and policy makers to take appropriate measures for mitigating the risk of negative outcomes.

Category: Diagnostic Audiology / Otology

Poster #: 158

Measuring U.S. Hearing Ability in NHANES: Past and Future

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Objectives: Data describing normal hearing levels, as well as the prevalence and co-determinants of hearing loss, are essential to targeting and evaluating prevention efforts. The National Health and

Nutrition Examination Survey (NHANES), which is administered by the National Center for Health Statistics, has collected hearing-related data in most survey cycles since its inception in 1959. Our goal is to describe historic and recent protocols for collecting audiometric data in NHANES, summarize estimates of hearing ability obtained from the NHANES program and describe trends over time, and discuss plans for NHANES hearing testing in the re-designed survey beginning in 2025.

Design: NHANES collects data on the health and nutritional status of the civilian, non-institutionalized US population through questionnaires, physical examinations, and laboratory analyses. The survey is cross-sectional and uses a complex, multistage, stratified, cluster design with oversampling of certain subgroups to ensure nationally representative estimates. Hearing testing in NHANES has always included pure-tone air-conduction audiometry at various frequencies. Certain cycles of NHANES have also included otoscopy, various immittance tests, and (rarely) speech and bone conduction audiometry.

Results: Approximately 60,000 survey participants have had their hearing tested in NHANES. For both children and adults, hearing thresholds have improved over the years. NHANES has also provided important insights into hearing ability and its association with cognition, hearing aid usage, and depression. One key finding from NHANES hearing data includes the increasing recognition of the association between cognitive decline and hearing loss (greater hearing levels were associated with lower scores on the digit symbol substitution test, or DSST) with hearing aid use positively associated with cognitive function (hearing aid users had a score difference of +7.4 on DSST compared to non-hearing aid users). However, this data also shows us that only about one-third of potential older adult hearing aid candidates reported current use of hearing aids. Another important finding is the association between hearing levels and depression in US adults (4.9% for individuals with good hearing and 11.4% for individuals with a little trouble or greater hearing difficulty). NHANES hearing data has also shown us that hearing levels have improved over the years in US children (improving considerably between 1966 to 1970 and 1988 to 1994) and adults (median thresholds were better in the 1999-2004 survey at 0.5, 3, 4, and 6kHz in comparison to the 1959-1962 survey).

Conclusions: NHANES has produced key estimates on hearing that have been used to set national policy and guide interventions. The methodologies that have been employed by NHANES over the past 60 years have changed as audiometry technology has improved. In the upcoming 2025 NHANES cycle, the mobile examination center (MEC) will be completely re-designed to create a more streamlined process for the participants and allow the survey to collect data in more locations each year. In order to accommodate this new design, the 2025 audiometry exam will be changing the protocol from audiometric booth testing to audiometric boothless testing. This poster summarizes the past and future methods of audiometric data collection and the steps being taken to ensure comparability of test results over time.

Category: Diagnostic Audiology / Otology

Poster #: 159

Preliminary Case Series of Longitudinal Audiological Changes in Young Veterans

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Objectives: US military personnel face many exposures that can damage the auditory system, including excessive noise. Traditional behavioral hearing testing may overlook this damage as research suggests noise-induced damage in the auditory system is possible even in the presence of normal behavioral hearing thresholds. This study evaluates audiological changes over time in young Veterans with normal baseline behavioral hearing thresholds.

Design: This study is a descriptive case series of seven Veterans (mean age=27.6). Participants were required to be 19-35 years old at enrollment, in good general health, and to have separated from military service within the past 2.5 years. Participants had no history of otologic or neurologic disorders, normal tympanograms, normal behavioral audiometric pure-tone thresholds, no air-bone gaps, no evidence of a noise notch, and robust distortion product otoacoustic emissions (DPOAEs) at enrollment. Participants completed comprehensive audiologic testing upon enrollment and at a follow-up visit that took place, on average, 7.4 years later. Audiologic testing consisted of tympanometry, pure-tone behavioral hearing testing (0.25-16 kHz), DPOAE testing (1.5-6 kHz, L1/L2=65/55 dB SPL), and auditory brainstem response (ABR) testing (wave I amplitudes to 4 kHz tone-bursts at 90, 100, and 110 dB peSPL), and the Speech Recognition in Noise Test (SPRINT). Participants were asked to complete a battery of questionnaires annually to assess tinnitus, noise exposure, and hearing difficulty. This study evaluates intra-participant audiological changes.

Results: Across participants, behavioral pure-tone threshold changes occurred more often at higher frequencies (mean change of 13.2 dB HL from 9-16 kHz), than lower frequencies (mean change=1.9 dB HL from 0.25-8 kHz). The participant with the largest threshold changes (mean change=16.7 dB HL from 0.25-16 kHz) at follow-up performed better on the SPRINT (16% increase), reported an increase in occurrence and decrease in subjective severity of tinnitus, reported new onset of sound tolerance problems, and did not have a meaningful change in wave I amplitude compared to their baseline.ABR wave I amplitude remained stable across timepoints for 5 of the 7 participants (change<0.1 μV). One participant had reduced wave I amplitude at follow-up while another had an increased wave I amplitude at follow-up. The participant with reduced wave I amplitude at follow-up also exhibited poorer behavioral thresholds at and above 8 kHz, poorer performance on the SPRINT (11% decrease), and increased occurrence and decreased subjective severity of tinnitus compared to their baseline. Similarly, the participant with increased wave I amplitude at follow-up demonstrated poorer behavioral thresholds at and above 9 kHz, continued constant tinnitus slightly decreased in subjective severity,

and stable performance on the SPRINT compared to their baseline. Neither participant with a wave I amplitude change reported sound tolerance issues at baseline or follow-up. Results and interpretation will be presented for each participant.

Conclusions: This case series describes changes in measures of auditory function and perception for seven young Veterans over time. Results varied by participant indicating further exploration of mediating factors and underlying mechanisms within this population is warranted. Comprehending domains of longitudinal changes in hearing is crucial to inform our approaches in preventing and rehabilitating hearing loss.

Category: Diagnostic Audiology / Otology

Poster #: 160

Hearing and Speech Perception in Individuals with Down Syndrome

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Objectives: The average lifespan of the 1/700 infants born with Down syndrome yearly is nearing 60 years of age, a five-fold increase since 1960. Hearing loss occurs commonly in this population (40-80%), resulting in challenges to communication, learning, socialization, and employment beyond those imposed by developmental and intellectual differences. However, hearing loss is frequently underdiagnosed and undermanaged in individuals with intellectual differences, including those with Down syndrome. Historic evidence suggests progressive high-frequency hearing loss for individuals with Down syndrome may begin as young as 11-20 years of age. Although the mechanisms for this are currently unclear, monitoring extended high frequency hearing beginning in early childhood may identify individuals with Down syndrome who are at risk for progressive loss, meriting more frequent assessment than described in current guidelines. The purpose of this study is to characterize hearing sensitivity in individuals with Down syndrome across the lifespan and to consider hearing abilities alongside linguistic knowledge and cognitive skills as contributions to speech perception in this population.

Design: Participants are children and adults with Down syndrome (≥ 6 years of age). Hearing sensitivity is assessed bilaterally at octave frequencies 0.25-8 kHz and at 10, 11.2, and 16 kHz, with the order of frequencies arranged to ensure a sampling of low, mid, and high frequencies bilaterally in case of early test termination due to fatigue. Bone conduction testing is done at frequencies with air conduction thresholds ≥25 dB HL (0.25-4 kHz). Tympanometry and wideband acoustic immittance is also completed. Masked speech recognition thresholds are estimated for disyllabic words in speech-spaced noise using an adaptive, four-alternative forced-choice task with a picture-pointing response. These procedures have been successfully used for masked speech recognition testing in our laboratory with neurotypical children as young as 3 years of age, Spanish-English bilinguals, and children with Down syndrome as young as 5 years of age. Participants also undergo neuropsychological and language testing.

Results: Data collection is ongoing, but the results obtained so far indicate a high prevalence of hearing loss at standard and extended high frequencies; conductive hearing loss occurs frequently, but mixed and sensorineural hearing loss also occur often. Similar to historic data, high frequency hearing loss emerges in early adolescence and is most severe for the oldest participants. Despite high rates of hearing loss, hearing aid use is uncommon. Preliminary data also show a trend for age-related improvements in masked speech perception. Linear mixed models will be used to analyze possible contributions of audibility-based factors and neuropsychological variables to masked speech perception.

Conclusions: Prioritization of high frequency hearing assessment may be warranted in clinical guidelines for individuals with Down syndrome. Masked speech perception assessment is feasible and may provide clinical insight into the way in which individuals with Down syndrome perceive speech in real world environments that include background noise.

Category: Diagnostic Audiology / Otology

Poster #: 161

Auditory Brainstem Responses in Down Syndrome: Effects of Stimulus Rate

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Objectives: Hearing loss is prevalent in individuals with Down syndrome (40-80%), conductive loss being the most common type. Auditory brainstem response (ABR) testing is often incorporated in assessment of hearing status in individuals with Down syndrome, and ABR peak latencies inform differential diagnosis of hearing loss type. Some data suggest differences in absolute and interpeak latencies between individuals with Down syndrome and neurotypical controls, but this is not consistently found. Latency assessment may be complicated by ear canal stenosis, observed in 30-80% of individuals with Down syndrome, which can increase stimulus levels at the ear drum by up to 15 dB for insert phones. In addition, waveform latency and morphology can be impacted by ABR stimulus rate; however, the effects of stimulus rate are not known in this population. The purpose of this study is to re-evaluate ABR peak latency measures in individuals with Down syndrome, focusing on stimulus rate effects, while incorporating strict control of in situ stimulus levels.

Design: Participants are children and adults with Down syndrome. In-situ ear canal levels during ABR testing are monitored using a probe microphone (ER-7C, Etymotic) under custom software control. ABRs are measured using the Vivosonic system with disposable surface electrodes at high forehead (non-inverting), ipsilateral mastoid process (inverting), and contralateral mastoid (ground) and impedances< 5 kΩ at the start of the test. First, behavioral threshold is measured for a click stimulus presented at rate of 27.7 clicks/sec. Next, ABRs are collected at 60 dB SL using stimulus rates of 11.1, 27.7, and 88.8 clicks/sec. Recordings are filtered (0.1-3 kHz) and ~2000 sweeps are obtained for each trace. Waveform morphology is monitored in real time for peak identification, with replication incorporated for confirmatory analysis. Waveform peaks marked during testing are reviewed by a second research team member blinded to condition. Discrepancies are resolved prior to data analysis.

Results: To date, data have been collected for 19 individuals with Down syndrome, from 7 to 41 years of age, with different degrees and types of hearing loss, and for a subset of age-matched neurotypical controls. Data collection is ongoing. Current data exhibit the expected trends of increased peak latency and loss of waveform morphology as stimulus rate increases, particularly for the highest rate (88.8/sec). Although inter-subject variability is high, on average Wave V latency appears similar between individuals with Down syndrome and neurotypical controls in some conditions. Pending additional data collection, trends will be further considered according to differences in degree and configuration of hearing loss across participants. Results will be discussed in the context of earlier studies of ABR characteristics in individuals with Down syndrome.

Conclusions: The effects of stimulus presentation rate and level may be important considerations to describe as part of clinical guidelines specific to ABR assessment in individuals with Down syndrome.

Category: Diagnostic Audiology / Otology

Poster #: 162

Investigation of Bone Conduction Thresholds with Head Coverings in Place

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Objectives: Bone conduction threshold testing is a foundational component of a comprehensive audiologic evaluation. Inaccurate bone conduction thresholds negatively impact patient management. It is not known whether testing bone conduction with a head covering (e.g., wig, cap, or hair scarf) in place affects the measured threshold. Current guidelines for bone conduction testing address touching the pinna and recommend removal of earrings, hearing aids, glasses, etc. to minimize interference with proper placement of the bone oscillator. However, no formal protocol currently exists for bone conduction testing for patients who wear head coverings. In preparation for the current research, a survey was developed to probe bone conduction testing protocols for various head coverings among licensed hearing care providers in the United States. We noted inconsistency amongst hearing care professionals about which head coverings are routinely moved or removed for bone conduction testing. Further, results for each specific head covering show a range of practices was observed. The current research investigates whether bone conduction thresholds and/or test-retest reliability are affected by a head covering worn during testing.

Design: Participants were recruited via flyers and emails sent to faculty and students. To date, data has been collected and analyzed for 22 subjects. It is expected that data collection will continue through December, 2023. Inclusion criteria were: age 18 or older with bone conduction thresholds 55 dB HL or

better at 1000-4000 Hz. For most participants, bone conduction hearing thresholds at all frequencies tested were within normal limits or no poorer than a mild hearing loss. Bone conduction thresholds were measured at audiometric frequencies from 250-4000 Hz in four conditions: uncovered (no head covering), wearing a wig, wearing a hair scarf, and wearing a baseball cap. We did not attempt to replicate a specific cultural application of any of these head coverings, but rather took a more general approach. For the wig and the hair scarf conditions, the oscillator was placed touching these items. Thresholds were obtained at both sides, two times per side. Two investigators were used so the hearing tester was blinded to the condition. If the bone conduction oscillator slipped during testing, the test condition for which it slipped was noted.

Results: Preliminary analysis using generalized estimation equations indicates that bone conduction thresholds obtained in the four conditions differed significantly ($p < 0.05$) at 250 Hz and 4,000 Hz only. Thresholds for the headscarf were 3-4 dB lower than for the other conditions at 250 Hz and were 3-5 dB lower at 4000 Hz. There was no effect of condition on test-retest reliability.

Conclusions: Although a statistically significant difference was seen, no clinically significant difference was seen for any of the three head coverings as compared with testing with no head covering. Based on these findings, the practice of moving or removing head coverings during bone conduction testing may not be necessary. Further research is warranted and the development of a protocol for testing bone conduction with head coverings in place is indicated to address this important aspect of cultural sensitivity.

Category: Diagnostic Audiology / Otology

Poster #: 163

Monitoring the Course of Endolymphatic Hydrops with a Joint Reflection-Distortion OAE Profile

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Objectives: Endolymphatic hydrops (EH) is a pathology involving an increased volume of endolymph in the cochlear duct. The ensuing alterations in cochlear morphology can cause disruptions in cochlear mechanics, including the generation of otoacoustic emissions (OAEs). Hence, OAEs may be an effective tool for diagnosing and monitoring the course of EH in humans. Here, in a handful of individuals with EH, we rapidly and jointly measure the two distinct classes of emissions-OAEs arising from nonlinear distortion and those arising from linear reflection-over the course of one year to better understand their utility and to define the reliability of both emission types in this group.

Design: A joint OAE profile was generated from the near-simultaneous measurement and relational analysis of distortion-product (DP) OAEs and stimulus-frequency (SF) OAEs. OAEs were recorded longitudinally (approximately every other month for one year) in ears with EH and in disease-free ears with normal hearing. Both OAEs were evoked with tones swept across five octaves and 10-12 stimulus levels at one octave per second. Stimulus level was calibrated in forward-pressure level and OAE level was corrected to emitted-pressure level. In this preliminary report: (1) we examine whether previously

documented effects of endolymphatic hydrops on OAEs persist across repeated test sessions (i.e., Are distortion emissions reduced more than reflection emissions?), and (2) we define the test-retest reliability of DPOAEs and SFOAEs in individuals with EH compared to normal hearers.

Results: Preliminary results from this longitudinal study show reduced or non-measurable DPOAEs in the region of EH involvement, combined with SFOAE levels that are less reduced or near normal. Although SFOAE levels are generally higher than DPOAE levels in normal hearers, most notably at low-to-mid frequencies and high stimulus levels, individuals with EH showed exaggerated differences between the two emission types, most of which can be attributed to selectively decreased DPOAE levels. A preliminary assessment of test-retest reliability showed that subjects with EH had more shifts in OAE level from test to test compared to disease-free individuals.

Conclusions: Consistent with a previous report from our group (Stiepan et al., 2023), the results suggest that OAE generation processes are disrupted by the pathophysiology of endolymphatic hydrops, which may include a stiffening of the cochlear partition and damage to the outer hair cell bundle. The intracochlear generation and/or transmission of nonlinear-distortion emissions may be more disrupted than that of coherent-reflection emissions. Additionally, OAE measurements are less repeatable in ears with EH compared to normal hearers. Data collection is ongoing.

Category: Diagnostic Audiology / Otology

Poster #: 164

Sensorineural Hearing Loss in Persons with Cystic Fibrosis-Related Diabetes

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Objectives: Permanent sensorineural hearing loss (SNHL) is often a condition in persons with diabetes mellitus due to microvascular complications and damage to the cochlea. Despite this available evidence, the potential associations of SNHL in persons with cystic fibrosis (PwCF) afflicted with CF-related diabetes (CFRD) have received limited attention. PwCF are already at high risk for ototoxic SNHL due to routine intravenous aminoglycoside therapies. Given the increased risk of permanent SNHL in PwCF due to treatment and medical complications, we explored the association between CFRD and hearing abilities in a cohort of PwCF.

Design: This analysis was ancillary to a larger prospective cohort study on genetics and hearing loss funded by the Cystic Fibrosis Foundation. Comparisons of hearing thresholds were made in PwCF with and without CFRD. Data were available for 41 PwCF with CFRD (Females= 22, Median age= 32.0y., Range= 9-61y.) and 62 PwCF without CFRD (Females= 28, Median age= 18.5y., Range= 7-67y). CFRD diagnosis was based on ICD9/10 coding determined by the managing clinician. All subjects were recruited from the CF Centers at Oregon Health & Science University from 2020-2022. Air-conduction

thresholds were obtained for 0.25-16.0 kHz and bone-conduction thresholds between 0.25-4.0 kHz using a standard Hughson-Westlake procedure documented in decibel hearing level (dB HL). Hearing loss was determined using the American-Speech-Language-Hearing Association (ASHA) classification system, with severity of loss ranging from mild to profound. Tympanometric testing using a 0.226 kHz probe tone was also used to rule out middle ear pathology. Data were analyzed using repeated-measures analysis of variance (R-ANOVA) with Bonferroni-Holm correction at $p<.05$.

Results: Preliminary analyses suggest that PwCF with CFRD had higher hearing thresholds for both the mean low-frequency (LF; 0.25-8.0 kHz) and high-frequency (HF; 9.0-16.0 kHz) regions bilaterally compared to PwCF without CFRD ($F1,4= 7.2$, $p=.008$). Mean LF thresholds for the CFRD group were 14.2 dB HL (SD=10.7) for the right ear and 12.82 dB HL (SD=10.7) for the left ear; whereas mean HF thresholds were 21.7 dB HL (SD=25.9) for the right ear and 20.6 dB HL (SD=27.0) for the left ear. In contrast, PwCF without CFRD exhibited lower mean LF thresholds at 8.8 dB HL (SD=7.1) right ears and 8.82 dB HL (SD=7.8) left ears. Mean HF thresholds were lower at 10.3 dB HL (SD=20.6) right ears and 9.2 dB HL (SD=20.5) for left ears. There was variability in hearing in both groups, ranging from normal to profound.

Conclusions: Our data suggests that PwCF exhibit worse hearing thresholds for the LF and HF test regions. These findings are consistent with existing literature on hearing loss in diabetes mellitus in the general population. In addition, both groups showed worse hearing in the HF, compared to LF test regions suggesting other contributing factors to hearing outcomes. The extent to which CFRD may contribute to SNHL risk of ototoxic drugs and environmental exposures remains to be determined. Continued investigation into the risk factors of CF comorbidities is important for the prevention of permanent hearing loss and promoting quality of life for PwCF.

Category: Diagnostic Audiology / Otology

Poster #: 165

Why Large 4-kHz Air-Bone Gaps? : Mechanical Impedance Perspective

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Objectives: In pure-tone audiometry at 4 kHz, a significant gap between measurements of air conduction (AC) and bone conduction (BC) has been consistently reported. However, the underlying cause for such a substantial gap remains unclear. The authors hypothesized that the significant individual differences in the mechanical impedance of human subcutaneous tissues may be a contributing factor, suggesting the presence of individuals with characteristics different from those used in calibration with artificial mastoids.

Design: The authors developed a device capable of measuring the mechanical impedance of subcutaneous tissues at the human mastoid under conditions identical to bone conduction audiometry. This device, composed of a force pickup and a vibrator, is attached to a headband used in bone conduction audiometry. Using this device,the authors investigated the relationship between the mechanical

impedance of each participant and the difference in hearing thresholds between air conduction and bone conduction. Audiometric measurements were conducted following the conditions specified in ISO 389-9, with a sample size of approximately 50 participants.

Results: Similar measurements of mechanical impedance to those obtained with artificial mastoids were achievable in humans, confirming the validity of the developed device. Moreover, the curves of mechanical impedance shown a characteristic folding pattern around the frequencies of 1 to 3 kHz, with individual variations at these frequencies. It was inferred that these individual differences in the folding frequency contribute to the significant gaps observed in air conduction and bone conduction measurements.

Conclusions: The study revealed significant individual differences in the mechanical impedance of human subcutaneous tissues, with individuals showing characteristics distinct from those used in calibration with artificial mastoids. To address the substantial gaps observed in air conduction and bone conduction audiometric values, it is suggested that future efforts should involve a reevaluation of bone conduction audiometry, considering individual differences in mechanical impedance, and a revision of the standards for bone conduction audiometry (ISO 389-3).

Category: Diagnostic Audiology/ Otology

Poster #: 166

Predicting Hearing Aid Preference from Self-Reported Listening Experiences in Daily Life

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Objectives: The study compared the power of two approaches for collecting real-world listening experiences to predict hearing-aid preference: retrospective questionnaire (Speech, Spatial and Qualities of Hearing Scale, SSQ) and in-situ Ecological Momentary Assessment (EMA). Moreover, it was examined how self-reported listening activity and hearing-aid data-logging can augment EMAs for individualized and contextualized hearing outcome assessments.

Design: Experienced hearing aid users (N = 40) with mild-to-moderate symmetrical sensorineural hearing loss completed the SSQ questionnaire and gave repeated EMAs for two wear periods of 2-weeks each with two different hearing-aid models that differed mainly in their noise reduction technology. The EMAs were linked to a self-reported listening activity and sound environment parameters (from hearing-aid data-logging) recorded at the time of EMA completion. Wear order was randomized by hearing-aid model. Linear mixed-effects models and Random Forest models with 5-fold cross validation were used to

assess the statistical associations between listening experiences and end-of-trial preferences, and to evaluate how accurately EMAs predicted preference within individuals.

Results: Only 6 of the 49 SSQ items significantly discriminated between responses made for the end-of-trial preferred versus non-preferred hearing-aid model. For the EMAs, questions related to perception of the sound from the hearing aids were all significantly associated with preference, and these associations were strongest in EMAs completed in sound environments with predominantly low SNR and listening activities related to television, people talking, non-specific listening, and music listening. Mean differences in listening experiences from SSQ and EMA correctly predicted preference in 71.8% and 72.5% of included participants, respectively. However, a prognostic classification of single EMAs into end-of-trial preference with a Random Forest model achieved a 95.2% accuracy when contextual information was included.

Conclusions: SSQ and EMA predicted preference equally well when considering mean differences, however, EMAs had a high prognostic classifications accuracy due to the repeated-measures nature, which make them ideal for individualized hearing outcome investigations, especially when responses are combined with contextual information about the sound environment.

Category: Diagnostic Audiology/ Otology

Poster #: 167

Audibility, Predicted Word Recognition, and Hearing Aid Adoption

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Objectives: Many persons who could benefit from a hearing aid do not adopt one. Studies have identified factors that are associated with hearing aid adoption: sex, stigma, perceived handicap, marital status, race, socioeconomic status, poorer word recognition and poorer pure-tone thresholds. The focus of our study was an analysis of the audiograms of hearing aid candidates who were followed longitudinally. We hypothesized that the hearing aid adoption rate (HAAR) would be associated with how well a candidate is predicted to understand speech presented at the level of normal conversation speech.

Design: Audiograms (732 adult participants, mean age 70) from the Medical University of South Carolina Longitudinal Cohort Study of Age-related Hearing Loss were shared with our research group following approval of a data sharing agreement between the two institutions. All participants were hearing aid candidates based on the following study criteria in either ear: SRT≥ 30 dB HL, or 3.0 and 4.0 kHz thresholds ≥ 40 dB, or, if the SRT was missing, pure-tone average (0.5, 1.0 and 2.0 kHz) ≥ 30 dB HL. Of the 732 participants, this study focused on 604 with symmetrical, sensorineural hearing loss. 30% of this group adopted a hearing aid. The Speech Intelligibility Index (SII) was calculated for better ears using the ANSI Standard for 1/3-octave bands for presentation levels of 40, 70, 75 and 80 dB HL. Threshold values for 1/3-octave bands at non-audiometric frequencies were interpolated and SII values were converted to predicted word recognition scores (WRS) for monosyllabic words.

Results: The distribution of predicted WRS for a presentation level corresponding to normal conversational speech (40 dB HL) was spread over a wide range compared to the distributions of WRS for higher levels (70, 75 or 80 dB HL) more typical of audiologic diagnostic exams. For persons with symmetrical losses (pure tone average difference for 0.5, 1.0, 2.0 & 4.0 kHz< 10 dB) and a conversational speech presentation level, WRS predictions of 80% and higher yielded only an 18% HAAR (25 adopted; 116 did not adopt). WRS predictions between 40-60% yielded a much higher HAAR of 43% (49 adopted; 66 did not adopt). WRS predictions for 40 dB HL were highly correlated with the four-frequency pure tone average (r2= 0.82). The correlation between predicted WRS and the pure tone average for higher presentation levels was much lower and the compressed distribution of WRS was less informative regarding HAAR.

Conclusions: Native English speakers with WRSs of 80% and higher have only minor problems understanding conversational-level speech with context in a quiet environment which likely accounts for the much lower adoption rate for persons mild losses. This finding suggests that hearing aid candidates with mild hearing loss may be less likely to perceive a need for hearing aids with potential implications for clinical practice and the emerging OTC hearing aid market. Further, the modest HAAR for persons with severe losses (approximately 40%) who are unable to understand speech at a conversational level shows that factors other than audibility play a large role.

Category: Diagnostic Audiology/Otology

Poster #: 168

Comparison of the Audiological Expertise of Chatbots Based on Artificial Intelligence

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Objectives: In recent times, there has been a notable surge in the development of AI-driven conversational tools, sparking extensive discussions regarding their utility and ethical considerations. Surprisingly, few studies have delved into the comparative performance of these chatbots. This study aims to fill this gap by assessing three prominent systems-OpenAI ChatGPT, Microsoft Bing Chat, and Google Bard-in their ability to respond to a specific set of audiological questions.

Design: All three chatbots were presented with an identical set of 10 questions, categorized as basic, intermediate, and specialized. The authors then evaluated the responses using a Likert scale ranging from 1 to 5. Additionally, the assessment included scrutiny for inaccuracies or errors within the answers. Various aspects of the responses, such as the word count, inclusion of references, and suggestions for seeking specialist assistance, were also systematically rated by the evaluators.

Results: The majority of responses from each of the three chatbots received a satisfactory rating or higher. Nevertheless, all chatbots exhibited a few errors or inaccuracies in their responses. ChatGPT garnered the highest overall score, while Bard performed the least favorably. Bard uniquely failed to provide a response to one of the questions but on the positive side consistently recommended consulting a specialist in all responses. Notably, ChatGPT was the sole chatbot that did not furnish information about its sources.

Conclusions: Chatbots serve as fascinating tools for accessing fundamental information in specialized fields like audiology. However, caution is advised, as accurate information is occasionally intertwined with subtle errors that may go unnoticed unless the user possesses a solid understanding of the subject matter. This issue becomes particularly pronounced in the case of ChatGPT, which lacks the routine provision of sources, making it challenging to discern the reliability of the information presented.

Category: Diagnostic Audiology/Otology

Poster #: 169

Sounding out Misophonia: Trigger Sounds and Coping Strategies

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Objectives: Misophonia, a distressing condition where people experience hatred (miso) of specific sounds (phonia), is a relatively unexplored condition that often results in devasting effects on personal and professional lives. Individuals affected by misophonia respond to highly specific trigger sounds with both intense emotional reactions (e.g., irritation, anger, rage, anxiety, disgust) and physical responses (e.g., muscle tension, sweating, increased heart rate). While this condition clearly involves audition, consensus is lacking on the involvement of auditory processing or acoustic characteristics of sound in the disorder. The objective of this study is to address the gaps in knowledge regarding the characteristics of misophonia by investigating whether there are patterns of acoustic characteristics of the sounds that trigger an emotional reaction, as well as to explore compensation strategies (earplugs, masking noise, etc.) used by individuals to cope with their response.

Design: Individuals 18 years and older who self-reported misophonia symptoms were invited to participate in an online survey. Following informed consent, participants completed the Duke-Vanderbilt Misophonia Screening Questionnaire (DVMSQ) scored according to published guidelines. Individuals who scored in ranges identified on the DVMSQ as having sub-clinical or clinical misophonia were given the option to continue to complete additional questions that regarding the status of hearing and other sound sensitivities, the acoustic characteristics of the sounds that trigger an emotional reaction, the onset and history of the symptoms, and the auditory-based compensation strategies (earplugs, masking noise, etc.) used by individuals to cope with their response. Ninety-two individuals currently have met the inclusion criteria of scoring in the sub-clinical misophonia (n=17) or clinical-misophonia (n=75) range on the DVMSQ.

Results: Preliminary data analyses have been performed on the ninety-two responses, with data collection ongoing. Consistent with previous literature, the most common trigger sounds include chewing sounds. Participant responses indicated that emotional reactions to trigger sounds are influenced by primarily by duration and intensity, but less influenced by pitch or sound location. Participants reported that their reactions worsen as trigger sound duration or intensity increases. The most used auditory-based coping mechanisms reported were increasing background noise, avoiding certain situations,

creating distance between themselves and the trigger source, leaving a situation, and listening to music using earphones. Of those methods, the most effective at both distracting an individual from the trigger sound as well as reducing the emotional reaction were avoiding and leaving situations were a trigger sound occurred.

Conclusions: Acoustic features of trigger sounds, like duration and intensity, impact individual experiences with misophonia. Additionally, earplugs and masking/background noises were generally not reported to be widely effective by participants. The most effective compensation strategies were reported by individuals as either avoid situations with trigger sounds or leave situations where they are exposed to these sounds. By knowing more about whether the acoustic features of sounds may impact an individual's experiences with misophonia, we hope to better develop the stimuli and protocols we use in future studies to examine the underlying auditory, physiological, and emotional neural foundations of the disorder.

Category: Diagnostic Audiology/Otology

Poster #: 170

Fast, Comprehensive Characterization of Middle Ear Muscle Reflex Dynamics

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Objectives: Measured clinically, the focus of middle-ear muscle reflex (MEMR) is on finding thresholds, and the protocol involves presenting elicitors at discrete levels and frequencies. In an effort to better understand MEMR dynamics, we assessed MEMR using a new fast test, in which a contralateral broadband noise elicitor continuously sweeps in level while a train of ipsilateral probe clicks is presented. Our protocol measured MEMR sound-level series in<1 dB step sizes across a broad range of elicitor levels. We characterized thresholds, growth rates, maximum activation, reflex delay, and hysteresis.

Design: Participants were 30 young, normal-hearing native English-speaking college students (ages 18-30, mean = 20.1 years, 16 females). Participants had pure-tone air-conduction thresholds ≤ 20 dB HL bilaterally for audiometric frequencies from 0.25-8 kHz. MEMR measurements were made using the ER10X probe system (Etymotic Research) and custom software written in MATLAB. Thevenin-source calibration was used to produce probe clicks and elicitor noise, both having flat acoustic spectra at the eardrum (0.1-20 kHz). A train of 95 dB peSPL clicks spaced 50 ms apart was presented to the ipsilateral (left) ear, and the noise was presented to the contralateral (right) ear. The elicitor was swept in level from 45 to 115 dB SPL, and back down to 45 dB SPL, in 8 seconds (17.5 dB/s rate). The sweeps were presented 15 times per test, for a total measurement time of approximately 2 minutes. The test was repeated four times for each participant, with the probe assembly removed, replaced, and recalibrated

for each test. Analysis: Each recorded ear canal pressure waveform in response to a probe click was time-windowed, transformed via FFT, and expressed as the complex change relative to the first response in the sweep. Changes were examined in 100-Hz bands from 0.125-8 kHz. Changes as a function elicitor level were used to compute MEMR thresholds (for both ascending and descending elicitor levels), growth rates, maximum change, reflex delay, and hysteresis.

Results: When changes in magnitude only were considered, some responses showed a non-monotonic relationship with stimulus level. Considering combined changes in both magnitude and phase resulted in monotonic changes, behavior consistent with increasing middle ear stiffness (increasing stapedius muscle contraction) with stimulus level. In addition to the sound level series produced by the contralateral elicitor, continuous slower changes were observed across the two-minute test, and these were found to be consistent with MEMR produced by the ipsilateral probe clicks.

Conclusions: Our new MEMR test measures MEMR threshold, growth rate, maximum change, reflex delay, and hysteresis in approximately 2 minutes. Significant amounts of hysteresis (fast changes across seconds that are dependent on direction of elicitor level change) and slower changes across minutes provide challenges as well as opportunities for improved understanding of the role of MEMR in hearing. Future analyses will correlate our novel measures with speech-in-noise performance that was assessed in the same ears used for the experiments reported here.

ELECTROPHYSIOLOGIC RESPONSES

Category: Electrophysiologic Responses

Poster #: 171

Assessing Audibility and Complex Processing in a Combined Evoked Potential

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Objectives: This study aimed to evaluate the sequential presentation of clicks and neurophonic vowels to assess biological signals of audibility and complex processing in a single test. A critical aspect of the objective was to vary stimulus parameters known to distinctly affect the Auditory Brainstem Response (ABR) and Frequency Following Response (FFR) when tested individually, thereby ensuring the validity of comparing these responses in a combined stimulus setting. We hypothesized that this combined stimulus approach would preserve the individual integrity of both the ABR and FFR tests.

Design: 20 young adults with no neurological disorders or hearing impairment were recruited. A standard 1-channel vertical ABR montage was applied to each participant and adjusted to an impedance<5 kOhm across and<2 kOhm within electrodes. The ABR was tested with clicks presented at two levels 70 or 40 dB nHL, and the FFR with synthetic /a/ vowels at 80 dB SPL, with either 100 or 200 Hz fundamental frequencies (F0s). Stimuli were presented in three pseudo-randomized blocks of ABR alone (ABR-A), FFR alone (FFR-A), and combined stimulus (ABR+).

Results: ANOVA and t-test revealed no significant differences in the ABR peak latencies or FFR amplitudes between the combined and individual tests across the varied levels and frequencies. This finding suggests that the combined ABR+ stimulus does not compromise the integrity of the individual responses under varied parametric conditions.

Conclusions: The study concludes that ABR and FFR can be sequentially combined without loss of individual test integrity, even under varied parameter conditions. This parametrically versatile approach offers an efficient method for assessing multiple auditory functions in a single test.

Category: Electrophysiologic Responses

Poster #: 172 **T35 Research Trainee Poster**

Neural Correlates of Auditory Comprehension in Williams Syndrome

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Objectives: Williams Syndrome (WS) is a rare genetic disorder causes by a deletion on chromosome 7 and associated with intellectual disability and a distinct cognitive profile. While language skills are a relative strength compared to visuospatial abilities, difficulties in auditory comprehension have been reported. This study investigated how hearing status, attention differences, and memory abilities contribute to auditory comprehension in WS. The use of cortical auditory evoked potentials (CAEP) that do not require active behavioral participation allowed to minimize the confounds of intellectual disability.

Design: Adults with WS (n=31: 18 male, 13 female; 18-50 years, M=30.96 years) attending a music camp completed a pass-refer hearing screening including otoscopy, tympanometry, and pure-tone air-conduction audiometry at 1k, 2k, and 4k Hz frequencies. To pass, participants had to respond at all frequencies bilaterally at 25dB. Auditory comprehension, attention and memory were assessed using CAEPs recorded with a 128-electrode montage. The active comprehension task presented spoken sentences with congruent or incongruent endings (120 trials). The participants reported whether each sentence made sense. The attentional load was manipulated by the distance between the main word setting up the sentence context and the ending (short: 0-2 words; long: 3+ words). The passive auditory memory task presented 51 single-syllable pseudowords, of which one was chosen at random and repeated 50 times, the rest were presented once (100 trials total). The participants were asked to listen the stimuli but not informed about the repetition. For both tasks, the auditory stimuli were presented at 75 dB SPL via a speaker placed above the participant's head. The amplitude and latency of the CAEPs quantifying the sensory (P1-N1-P2) and higher-order cognitive responses (semantic N400, parietal old/new response at 300-500 ms) were analyzed.

Results: We observed a high prevalence (39%) of referred hearing screenings in participants with WS, most likely had a mild hearing loss. Sensory CAEPs (P1-N1-P2) were observed for spoken words in active and passive listening tasks and were not affected by hearing status. Neural evidence of auditory comprehension was indicated by a significantly more negative N400 amplitude for incongruent than congruent endings regardless of sentence length. Compared to participants who passed the hearing screening, those who referred had increased N400 latency for the incongruent sentences. Evidence of

auditory memory for repeated stimuli was reflected in a more positive parietal CAEP amplitude at 300-500 ms. There were no significant associations between parent-reported attention difficulties and behavioral or neural auditory comprehension measures.

Conclusions: Hearing status showed the clearest effect on auditory comprehension reflected in slower neural processing of semantic conflicts in spoken inputs, even when sound onset detection was typical. The participants' behavioral or neural responses were not affected by sentence length, suggesting sufficient attentional abilities to support auditory comprehension in a casual setting. We observed neural evidence of auditory learning and memory for novel stimuli that was not affected by hearing status, at least for the small memory set used. Thus, professionals working with individuals with WS should monitor their hearing status across the lifespan to maximize their communication competence and quality of life.[Supported by NIH-NIDCD T35 DC008763]

Category: Electrophysiologic Responses

Poster #: 173

Exploring Speech-Evoked N400 Responses in Children with Listening Difficulties

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Objectives: Listening difficulties (LiD), a collection of symptoms that include impaired perception of speech under degraded or noisy conditions, among other challenges, are often reported by individuals with little or no peripheral hearing loss. In the context of Auditory Processing Disorder (APD), a clinical construct that is marked by LiD, such symptoms were historically ascribed to deficits in central auditory processing. However, a recent body of research using a large sample of children with LiD has revealed little evidence of central auditory deficit. Rather, children with LiD show poor cognitive function versus their typically-developing (TD) peers, including altered cortical processing of speech, as measured via functional magnetic resonance imaging. The goal of the present study was to examine whether LiD is marked by alterations in the N400 evoked response to speech stimuli, a response that reflects semantic integration.

Design: Twenty-four (12 with LiD as reported on the ECLiPS, 12 TD) children, ages 8-15 years old, listened to a 16-minute story, which was altered using a method known as Chirp Speech to synchronize the neural response and more effectively evoke responses across the central auditory nervous system. The story was delivered diotically at 70 dB SPL via ER-2 inserts, while EEG data was collected from 52 scalp sites. To measure modulation of the N400, onset responses to the nouns of the story were analyzed with respect to linguistic frequency in American English (as obtained from the Corpus of Contemporary American English, for the years 2015-2019).

Results: As expected, the neural response to low-frequency words (i.e., words that are more rarely used in American English) was characterized by the enhancement of the N400 response 400-600 ms from stimulus onset at posterior sites, but this effect was very small. Additionally, the response to high-frequency words was marked by an anterior negativity that began very early after word onset (approx. 50 ms post-onset). However, neither of these responses distinguished children with LiD from their TD peers.

Conclusions: The results of this study confirm that modulation of the N400 by word frequency is generally weak. The observed early enhancement of processing for frequent words mirrors other research that has reported enhanced early processing for words vs. pseudowords in adults, perhaps reflecting a distinction between words that the children knew and those that they did not. Neither effect was compromised in children with LiD. Further optimization may be necessary to identify the most robust linguistic features to target for obtaining N400 responses that differentiate children with LiD from their TD peers.

Category: Electrophysiologic Responses

Poster #: 174

Movement Effects on Brainstem Responses Collected with Earphones Versus Soundfield

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Objectives: Auditory brainstem responses (ABRs) are helpful in research and the clinic for evaluating hearing function at the early stages of the auditory pathway. ABRs are typically collected using sound presented through insert earphones. Validating ABRs to sound through speakers may allow for better understanding of the neural basis of speech processing within more natural environments and new tools for assessing hearing aid function. This pilot study evaluated the effects of systematic head movements in the yaw, pitch, and roll directions on ABRs collected in soundfield and insert conditions. We hypothesized that lateral head movements would degrade ABRs the most due to the jitter in timing introduced by the ear location relative to the speaker, and could be adjusted for by recording the head movement.

Design: To date, five participants with normal hearing (ages 21 to 39 years) have been recruited. Two-channel ABRs were recorded while the participant sat in a chair positioned before a speaker at 0 degrees azimuth. During the recording, participants listened to 14 minutes of randomized clicks and were instructed to keep their heads still or move in three directions: yaw, pitch, and roll. Each movement accounted for 3.5 minutes of testing and was presented in randomized 10s segments. Head movements were monitored via two methods. First, a webcam collected head angles along an x, y, and z axis from the camera using the open source python MediaPipe library, and then provided visual feedback to the participants when they were not still. Second, an analog gyroscope placed on the inion, under the recording cap, measured the head's x, y, and z positions. ABR waveform morphology was compared, and Spearman correlations were calculated for a 10ms window encompassing the ABR. For the preliminary analysis, peak ABR latencies and amplitudes were compared using linear mixed-effects regression with participants as a random effect and transducer and head movement as fixed effects.

Results: Preliminary analyses show that ABRs with visible peaks were recorded in all head movement conditions and for stimulus presentation over speakers and insert earphones. As expected, ABRs were sharper and less noisy in the head still than the movement conditions. Some participants exhibited the postauricular muscle response during the movement conditions. The specific changes to ABRs across all conditions will be further investigated. Additionally, the data collected from the MediaPipe recordings and gyroscope will be further analyzed in each movement (or still) condition.

Conclusions: The results from this pilot study show that measuring ABRs in the soundfield is possible with some movement. Future analyses of the head movement measurements will inform whether correcting for these movements may improve these ABR recordings. If feasible, testing in the soundfield without head bracing would allow for more naturalistic testing and expand testing paradigm options for a diverse set of patient populations.

Category: Electrophysiologic Responses

Poster #: 175

WITHDRAWN

Category: Electrophysiologic Responses

Poster #: 176

Oscillatory Mechanisms Underlying Phonological Processing during Attentional and Working Memory Demands

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Objectives: Effective speech perception in difficult listening situations requires sustained attention and constant updating and manipulation of information stored in the working memory, Electroencephalogram (EEG) can be an effective tool that can be used to assess differential processing of speech sounds in the brain in presence of working memory and attentional demands. Neural activity in different EEG frequency bands /oscillations has been demonstrated to provide window into the top-down and bottom-up computational processes underlying speech perception. Alpha band (8-12 Hz) desynchronization is theorized to reflect increased attention via suppression of irrelevant information. Theta band (4-7 Hz) modulation, especially in frontal midline areas, has been shown to play an important role in attention control. Sustained attention modulates beta band (12-38 Hz), which is suppressed during motor movement. However, little is known about how these oscillatory mechanisms contribute to phonological processing, and how they are modulated by working memory and attentional demands. In the present study, we explore how these oscillations are modulated in a task which engages working memory and requires sustained attention. Further we will also assess if these oscillatory signatures underlying phonological processing are affected by task-related fatigue.

Design: Electroencephalography (EEG) from 64 channels was recorded while participants performed n back tasks (no-back and 2-back). Twenty-two participants in the age range of 18-26 years listened to an auditory stream of six different CV syllables presented randomly in no-back condition. Participants pressed a button when they heard the same syllable as 2 prior in 2-back condition. The 2-back condition requires sustained attention while memorizing and retrieving the speech sound constantly and comparing it with what they heard recently. Data analysis is in progress. Data analyses will involve time-frequency analysis to obtain event-related spectral perturbations (ERSP), which is a metric of activity across different oscillatory bands. The ERSPs will be compared between two conditions using permutation statistics to infer the effects of working memory and attention demands on the encoding of the speech syllables. Effects of task-related fatigue will be assessed by comparing the data in the first and last half of the task.

Results: We hypothesize that the ERSP across the alpha, theta and beta bands will be significantly different in 2-back condition compared to the no-back condition. We also hypothesize that the effect of fatigue would modulate the amplitudes of these bands between the first and last half of the task while maintaining sustained attention and increased working memory demands.

Conclusions: The results will help us understand how different oscillatory bands in EEG are modulated during increased attentional and working memory demands, which will give us insight into the computational processes underlying speech processing in demanding listening situations. Further, we will also uncover oscillatory signatures underlying task-imposed fatigue on neural processes underlying speech processing.

Category: Electrophysiologic Responses

Poster #: 177

Interaural Asynchrony Influencing Bilateral Benefit in Speech-Evoked Envelope Following Responses

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Objectives: Speech-evoked envelope following responses (EFRs) could be a promising objective method to assess access to speech with hearing aids. However, past work has investigated the utility of speech-evoked EFRs to evaluate hearing aid benefit only when stimuli are presented unilaterally. Since hearing with both ears better reflects real-world listening, the objective of the present study was to evaluate whether speech-evoked EFRs continue to be effective indicators of access to speech when stimulation is bilateral, irrespective of a hearing aid being worn in one or both ears. We hypothesized that the benefit of bilateral over unilateral stimulation while assessing access to speech depends on the difference in processing time between the ears, as well as whether brainstem or cortical dominant EFRs at the

fundamental frequency (f0) and syllabic rate, respectively, are being measured. We predicted that a unilateral hearing aid fitting, that introduces a processing delay of 5-6 ms in one ear alone, would negatively influence f0-EFRs more than syllabic-rate-EFRs.

Design: A total of 22 young adults with normal hearing participated in the study. A male-spoken "sashi", modified to elicit six frequency-specific f0-EFRs, was presented through ER2 insert earphones to each ear and to both ears, once synchronously and once with a 5.6 ms hearing aid processing delay simulated in one ear. Electroencephalogram was recorded between the vertex and the nape of the neck for 400 stimulus trials. For the f0-EFRs, the response amplitude to each of the six stimuli that included the low frequency first formants of vowels (F1), the mid frequency second and higher formants (F2+) of vowels, and the fricatives were analysed using a Fourier analyser or discrete Fourier transform. For the syllabic-rate-EFRs, the response amplitude was assessed at 1.56 Hz (the syllabic rate) and the 2nd harmonic using fast Fourier transform.

Results: For all stimuli, the f0-EFR amplitudes did not vary significantly between the two unilateral conditions. The f0-EFR amplitudes in the bilateral synchronous condition was approximately twice as large as each of unilateral conditions. The unilateral HA use simulation condition led to lower f0-EFR amplitudes than all other conditions. Syllabic-rate-EFRs are yet to be analysed.

Conclusions: A clear benefit of testing bilaterally is evident for f0-EFRs when stimuli are synchronous between the ears. However, a unilateral hearing aid fit during bilateral stimulation can lead to very small f0-EFRs, smaller than either unilateral condition, possibly due to scalp-level destructive interference. Planned analysis will help elucidate whether syllabic-rate-EFRs are more robust to asynchrony between the ears due to unilateral hearing aid processing delays.

Category: Electrophysiologic Responses

Poster #: 178

Electrophysiological Evaluation of an Adaptive Region Beam in Multi-Talker Situations

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Objectives: Beamforming is often used by modern hearing aids to support highly directional microphone systems that can help wearers follow speech in challenging acoustic environments. However, the spatial enhancement provided by traditional beamformers is restricted to regions directly in front of the wearer. Narrow beam angles may then cause listeners to miss speech arriving from talkers located to the side of the beam. In this study, we use electroencephalography (EEG) to evaluate the efficacy of a novel directional algorithm, known as the adaptive region beam (ARB), which can expand its beam angle to include target signals originating from multiple frontal azimuths. Theoretically, such an algorithm should provide speech-in-noise enhancement for speech originating from in front of the listener, akin to traditional beamforming, as well as for speech originating from secondary locations to the sides. The efficacy of the ARB is evaluated based on pre-attentive cortical indices of phonemic discrimination, via

the mismatch negativity (MMN), and oscillatory activities (i.e., alpha-band power) associated with listening effort.

Design: Eighteen older adult listeners (mean age = 72.8 years ±10.4 SD) with sensorineural loss were tested using study aids programmed with either ARB or non-ARB processing. To evaluate pre-attentive speech-in-noise efficacy, participants first completed a psychophysical task to determine their phonetic discrimination thresholds for /ba/ versus /da/ stimuli presented from a single front loudspeaker (0° azimuth) in the presence of continuous loud (SPL = 75 dB) cafeteria noise presented from 3 loudspeaker in the back (145, 180, and 215° azimuth). The MMN was then measured for ARB and non-ARB programs while participants were presented with an oddball sequence (800 trials; 15% deviant) of /ba/ and /da/ stimuli at a level determined by the preceding behavioral task in the presence of the same loud cafeteria noise. Notably, the location of the test stimuli now alternated on each MMN trial between loudspeakers positioned at 0° and -35° in the azimuth to simulate a multi-talker turn-taking situation.To evaluate the effect of ARB on alpha-band power, an adaptive sentence-level speech-in-noise test, using the noise configuration described above, estimated 50% speech-reception thresholds (SRT50s) in the ARB mode. Alpha-band power was then measured for ARB and non-ARB programs while participants performed 60 trials of the speech-in-noise task at an SNR corresponding to each listener's SRT50. During testing, presentation of the speech materials alternated between two loudspeakers positioned at 0° and -35° in the azimuth.

Results: As expected, ARB processing significantly enhanced MMN amplitudes compared to the non-ARB mode ($\chi2(1) = 5.13$, $p = 0.024$). In addition, alpha-band power was significantly reduced when listeners performed the speech-in-noise test in the ABR compared to the non-ARB mode ($\chi2(1) = 55.14$, $p< 0.001$).

Conclusions: The ARB enhanced listeners' tracking of changing phonemes originating from two frontal locations compared to non-ARB directionality. Lower alpha activity measured in the ARB mode compared to the non-ARB mode, along with the passive nature of the MMN protocol, suggests that the benefits of ARB are bottom-up in nature.

Category: Electrophysiologic Responses

Poster #: 179 **Mentored Student Research Poster Award**

Envelope Following Response and Auditory Brainstem Response as Potential Biomarkers of Central Compensation Following Selective Inner Hair Cell Loss

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Objectives: In animal models, cochlear damage has been shown to produce compensatory central gain from the auditory system. Despite the well-known association between peripheral acoustic injury and central compensation in animals, we lack sensitive correlates of central auditory gain that can be applied to humans in both clinical and research settings. Here, we assess the utility of using clinically feasible electrophysiological assays such as the envelope following response (EFR) and the auditory brainstem

response (ABR) to assess changes in central auditory gain following selective inner hair cell (IHC) loss in the chinchilla animal model.

Design: Young adult (2-3 years old) chinchillas were used in this study. Cochlear nonlinearity, hearing sensitivity, and auditory neural pathways were evaluated by assessing distortion product otoacoustic emissions (DPOAEs), ABR thresholds, ABR wave 1-5 amplitudes, and EFR amplitudes. EFR was elicited using amplitude modulated (AM) tones (AM depths: 100%, 80% and 20%; AM rates: 40 Hz and 88 Hz). All measures were obtained before and after selective IHC loss induced by a single dose of 75 mg/kg of carboplatin (i.p.). ABR and EFR were reassessed after a three-week recovery period. Post-exposure changes in ABR wave 3/1, 5/1 and 3/5 amplitude ratios and EFR amplitudes were evaluated as potential markers of central compensation following selective IHC loss.

Results: Histological results showed 60-80% loss of IHC with little-to-no loss of outer hair cells. Carboplatin treatment yielded a significant reduction in ABR wave 1 amplitude with no change in DPOAE amplitudes or ABR thresholds. Following IHC loss, we observed a significant increase in ABR wave 3/1, 5/1 and 3/5 amplitude ratios, a significant reduction in fast-rate EFR amplitudes, and no significant change in slow-rate EFR amplitudes.

Conclusions: Enhanced central auditory gain secondary to selective IHC loss can be detected via far-field ABR and EFR recordings in the chinchilla animal model. These results suggest that central compensation following reduced peripheral sensory input may be elucidated via electrophysiological assays that are accessible to clinical settings.

Category: Electrophysiologic Responses

Poster #: 180

Cortical Encoding of Fundamental Frequency Contour Cues to Emotional Prosody

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Objectives: Accurate identification of speakers' emotional status from their speech is crucial for social communication. The ability to identify speech emotions declines with advancing age, reducing the quality of social interactions in older adults. To date, mechanisms underlying such age-related declines in speech emotion identification remain less understood. Emotional prosody is critical for speech emotion

identification and is conveyed primarily via dynamic fundamental frequency (F0) cues. Thus, age-related changes in the sensitivity to dynamic F0 cues likely contribute to age-related declines in speech emotion identification. To evaluate such a hypothesis, the current study first examined the extent to which advancing age affects the neural encoding of dynamic F0 cues to emotional prosody.

Design: Younger to older adults with normal hearing were recruited to perform an emotion categorization task on a 5-step continuum of F0 contour cues (duration = 789 ms) while 64-channel cortical electroencephalographic activity was recorded. The F0 contour continuum was created from the utterance "time to go," with the endpoints corresponding to "happy" and "sad" emotions. Participants were required to categorize each stimulus from the continuum as expressing a "happy" or "sad" emotion. Behavioral categorization performance and cortical event-related potentials (ERPs) to the F0 contour cues were analyzed. Preliminary analyses were based on 12 normal-hearing participants, including ten younger adults (< 35 years old) and two middle-aged adults (between 45 and 65 years old).

Results: Behaviorally, all participants were able to use the F0 contour cues to categorize happy vs. sad emotions. For the ERPs, middle-aged participants, compared to younger participants, appeared to exhibit delayed earlier responses (e.g., P2 peak) and smaller (or more positive) later responses (e.g., after 400 ms). Different F0 contours appeared to elicit responses with varying amplitudes. For instance, F0 contours toward the "happy" emotion, relative to those toward the "sad" emotion, appeared to elicit smaller earlier responses (e.g., the N1-P2 complex) and smaller (or more positive) later responses, particularly among younger participants. Finally, the ERP amplitude changes with F0 contours appeared to partly align with the behavioral categorization performance in the majority of participants.

Conclusions: The preliminary results revealed ERP measures reflecting neural encoding of F0 contour cues to emotional prosody, which appeared to change with age. The current study has implications for elucidating the neurophysiological mechanisms for age-related declines in speech emotion identification.

HEARING LOSS / REHABILITATION

Category: Hearing Loss / Rehabilitation

Poster #: 181

Audiology Inpatient Management: Improving Outcomes with Bedside Services

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Maureen Wargo, *AuD*, *VA Pittsburgh Healthcare System*, *Pittsburgh*, *Pennsylvania*

Objectives: The negative impact of untreated hearing loss on healthcare outcomes is well-documented in the literature but underrecognized by medical providers. While hearing loss is evaluated and treated at outpatient audiology clinics, inpatients with hearing loss are often without amplification upon admission. Patients must hear providers to discuss important health-related information, such as treatment options and discharge instructions, during their inpatient stay. The audiology department at a large medical center began a program to better inpatient care by providing nursing in-service and bedside audiologic services, such as repairing hearing aids, issuing a personal amplifier, or counseling on effective

communication strategies, to patients with hearing loss. The purpose of audiology inpatient management (AIM) is for patients with hearing loss to understand their medical providers during a hospitalization. Since implementing AIM, we hypothesize that: non-audiology healthcare providers' ability to recognize the need for audiologic services will increase; providers will be able to effectively and succinctly communicate with a patient; patients will save at least one separate outpatient visit by receiving audiologic services at bedside; patients will value AIM services; patients' satisfaction with their overall hospitalization will increase; the readmission rate of inpatients with hearing loss will decrease by improving their ability to participate in care.

Design: AIM was piloted on a single inpatient unit in March 2021 and has since expanded to every unit as of May 2023. Medical informatics created a list of current inpatients with hearing loss on their electronic medical record's "problem list" to whom bedside services were provided at least once per hospitalization. A survey was developed to assess the perceived satisfaction of patients and providers. Retrospective analyses of the electronic medical record are planned to quantify the benefit of AIM by comparing audiology consults, services provided, readmission rates, and responses to surveys of inpatient experience between 2019 and 2023.

Results: Before implementing AIM, audiology was only consulted once in a three-month period to provide services for an inpatient with hearing loss on the pilot unit. However, from March-December 2021, 45% of new inpatient admissions to the pilot unit had previously documented hearing loss. Additionally, from February-December 2022, 64% of inpatients who previously received hearing aids from the audiology department did not bring them to the hospital upon admission. In the first eight months of AIM, inpatients with hearing loss receiving audiologic services increased by 3900% compared to baseline and saved 80 separate outpatient visits. Program expansion was encouraged by inpatient consults to audiology outside of the pilot unit and positive feedback from medical providers.

Conclusions: Results suggest an unmet need for inpatient audiologic services. This work is being used to inform staffing considerations, promote interdisciplinary collaboration, and improve the AIM process at our medical center. Ultimately, results will guide recommendations on how to ensure inpatients with hearing loss can effectively participate in their healthcare. A portion of this work was presented at the Joint Defense Veterans Audiology Conference, March 6-8, 2023.

Category: Hearing Loss / Rehabilitation

Poster #: 182

Provider Perspectives on Barriers to Implementing Ototoxicity Management at VA

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Objectives: Successful implementation of ototoxicity management (OtoM) relies on collaboration between audiology and oncology services. The goal of this study is to describe perspectives of Veterans Affairs (VA) audiology and oncology providers on aspects of OtoM, service delivery gaps, and barriers to care. A secondary objective is to use demographic data to characterize Veterans who received ototoxic chemotherapies and their audiology service utilization. Ultimately, results from cancer survivors, audiologists, and oncology providers will be used to inform a clinically-relevant approach to implementing high-impact OtoM across the VA healthcare system.

Design: The Ototoxicity Management Through Interdisciplinary Care (OtoMIC) survey was developed and validated by an interdisciplinary team. It includes 26 questions mapped to three constructs of the Consolidated Framework for Implementation Research: (1) inner setting (e.g., structural characteristics of the healthcare system/facility), (2) outer setting (e.g., patients' needs and resources committed by the organization to address these needs), and (3) individuals involved (e.g., provider experience, knowledge and beliefs, and other personal characteristics). A request for participation was emailed to 221 clinicians across the country and responses were obtained from 96 VA audiology, oncology, and pharmacy providers. The quantitative data from the survey were analyzed using descriptive statistics. The qualitative data from the survey were analyzed using a deductive thematic analysis. To compliment survey responses, data were also extracted from the VA Cancer Registry and Corporate Data Warehouse to determine the scope of ototoxic chemotherapeutic use in VA (i.e., cisplatin, carboplatin, or oxaliplatin), and audiology service use for patients receiving these platinum-containing cancer treatments.

Results: One hundred percent of audiology and 94% of oncology team respondents reported that some form of OtoM is necessary for patients receiving cisplatin. The majority (100% for audiology and 70% for oncology) also endorsed the need for OtoM for patients receiving carboplatin. While results suggest that a pre-treatment baseline, the ability to detect ototoxicity early, and management of ototoxic effects during and after treatment are high-value objectives for both groups, oncologists perceived more utility in point-of-care and at-home screening than audiologists. Additionally, oncology team respondents reported that they feel that they are more responsible for discussing ototoxicity risk than audiologists. Common barriers to effective OtoM include an underestimation regarding the prevalence of ototoxicity, disagreement over hearing testing schedules, lack of interprofessional communication, and misalignment concerning which provider is responsible for various aspects of OtoM. Although providers value OtoM, only 50% of audiology and 70% of oncology team respondents reported that OtoM is being provided for patients receiving cisplatin at their facility. This estimate contrasts with VA administrative data, where fewer than 10% of patients who received cisplatin accessed audiology services at least once in the period

of 1 month before to 1 year after their first chemotherapy treatment. Most (>95%) patients receiving carboplatin or oxaliplatin did not access audiology services at all.

Conclusions: The OtoMIC survey provides clinician perspectives to benchmark and address gaps in OtoM. Results will guide recommendations on OtoM across the VA, including promoting interprofessional collaboration, eliminating barriers to care, and emphasizing practices that stakeholders perceive positively influence patient outcomes.

Category: Hearing Loss / Rehabilitation

Poster #: 183

Global Prevalence of Hearing Loss and Hearing Aid Use

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Objectives: Hearing loss (HL) is increasingly recognized as a global health issue, given both the salience of age-related HL in an aging world and the negative impact that HL can have on a variety of life domains. Hearing aid (HA) uptake is typically low, despite their mitigating effects. Much research on HL prevalence and HA-use considers objective measures of HL, which are crucial for understanding population-level differences in HL; however, self-reported measures may be preferable in understanding the day-to-day challenges experienced by adults with HL. Moreover, because objective measures are expensive to collect and typically available only for high-income countries, there is limited research on the patterns of HL and HA-use in low- and middle-income countries. The current study aimed to contribute to the literature on HL and HA-use by 1) investigating self-reported hearing and HA-use in 25 countries, and 2) examining how these patterns vary by gender.

Design: Data are from eight surveys, representing 25 countries (2000-2021): Brazilian Longitudinal Study of Aging (2016-2020); China Health and Retirement Longitudinal Study (2011-2018); Costa Rican Longevity and Healthy Aging Study (2005-2009); Survey of Health, Ageing, and Retirement in Europe (2004-2015); Mexican Health and Aging Study (2001-2021); South African National Income Dynamics Study (2008-2017); Korean Longitudinal Study of Aging (2006-2020); and Health and Retirement Study (USA) (2000-2018). A total of 643,211 individuals aged 50 and older with complete information on self-reported hearing (while using a HA as normal, if applicable) and HA-use are included. We define HL as either: 1) self-reported fair/poor hearing, or 2) self-reported HA-use. We calculate age-standardized prevalence of HL and HA-use over time and by gender based on the mean age distribution of the populations from included countries for the year 2020. We calculated age-specific prevalence of HL and HA-use by gender for each country. To better understand gender disparities within and between countries, we computed a male:female ratio of HA users to individuals with HL.

Results: The prevalence of HL increased by age in all countries. Men were typically more likely to report HL than women, though the ratio of male:female HL ranged widely across countries. The gender gap was largest in the USA and parts of Europe, with men being nearly twice as likely to report HL at some ages. In

contrast, men and women were equally likely to report HL in China, South Korea, and South Africa. HA-use ranged from<3% of the general population in China to >25% of the USA population at older ages. Among adults with HL, men in China, South Africa, and South Korea were often more than twice as likely as women to use HAs. The female disadvantage in HA-use was smaller or non-existent in other countries.

Conclusions: The wide range of gender differences in self-reported HL and HA-use across examined countries suggests the importance of country contexts in shaping HL and access to hearing healthcare. Understanding these patterns is crucial for promoting healthy aging and maintaining the well-being of older populations around the globe.

Category: Hearing Loss / Rehabilitation

Poster #: 184 **Mentored Student Research Poster Award**

Visual Social Attention and Pragmatics in Adolescents who are Deaf/Hard-of-Hearing

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Objectives: Children who are deaf/hard-of-hearing (DHH) and use spoken language often demonstrate differences in pragmatic language abilities compared to typically hearing (TH) peers, even in the presence of typical receptive and expressive language. At present, a clear mechanism accounting for the relation between hearing loss and pragmatic language has not been identified. This preliminary study tests one possible mechanism: visual social attention.

Design: Twenty TH and 7 DHH adolescents with hearing technology participated in the study. All were between 10-13 years with typical non-verbal cognitive ability. Pragmatic language was assessed using standard behavioral, parent questionnaire, and examiner observation measures. Measures of language, executive function, and theory of mind were also administered. Visual social attention was assessed in two contexts: live conversation and watching recorded movie scenes. Eye gaze from live conversation was analyzed from video using the ELAN coding software, and eye gaze from the recorded context was analyzed using the Tobii Pro Spectrum eye tracker.

Results: DHH adolescents scored significantly lower than the TH group on all three pragmatic assessments, based on non-parametric tests of group differences (behavioral: $W = 62.5$, $p = .048$; parent-report: $W = 31$, $p < .001$; examiner observation: $W = 54.5$, $p = .013$). Group differences were observed on eye gaze behaviors in both contexts. In the recorded context, DHH adolescents looked significantly more at the mouth of a speaking character compared to TH adolescents, $t = -4.41$, $p < .001$, based on pairwise comparisons from a mixed effects model. In the live context, DHH adolescents looked significantly more at the face of a conversational partner while the participant was listening, $W = 107$, $p = .041$, compared to TH adolescents; there were no group difference in looking time toward the face while speaking, $W = 87$, $p = .37$. Principal component analysis of subcomponents from all pragmatic assessments revealed three components. Correlations among eye gaze and pragmatic components from the PCA revealed a relationship between one of the PCA components (the perspective-taking ability component, or "higher-level pragmatics") and eye gaze behavior in the live context only. Multiple regression analysis predicting higher-level pragmatic abilities from eye gaze in live conversation was significant, $F(8, 18) = 8.26$, $p <$

.001, revealing that overall eye gaze toward the face of a conversation partner (while speaking and listening) predicted higher-level pragmatics in the DHH group only, t = 2.85, p = .011.

Conclusions: The results support findings showing differences in pragmatic language abilities between DHH and TH adolescents. This is the first study to demonstrate that increased attention toward the face while speaking and listening in live conversation relates to stronger higher-level pragmatic abilities in DHH adolescents. These preliminary results have direct applicability to therapeutic interventions, which historically have placed greater emphasis on auditory input for spoken language development. Results from the current study suggest that clinicians consider integrating pragmatic language goals into therapy, including practice with perspective-taking. Future longitudinal work with a larger sample should test the directionality of these variables, revealing whether visual attention affects later pragmatic language development.

Category: Hearing Loss / Rehabilitation

Poster #: 185

Partnership-Centered Audiology for Older Adults with Hearing Loss

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Objectives: Previously we reported on partnership-based audiology services for older adults with hearing loss (Gianakas et al, AAS 2023). We noted that hearing loss affects both the client and their close family and friends (partners), and that there is often a mismatch in the perception of hearing loss between the client and partner. We have continued this work to further explore the social and emotional experiences of adults with hearing loss and their partners regarding their success with hearing aids. The goal of this work is to increase empathy and understanding of the impact of hearing loss on communication for both parties. A long-term goal of this work is to expand audiologic best practice to include close family members in counseling around hearing devices as a tool in a broader set of communication strategies.

Design: Older adult clients with hearing loss and their most-frequent communication partner completed remote interviews and questionnaires related to the impact of the client's hearing loss. Participants (clients and partners) separately completed the SPARQ, HHIE, and SOS-HEAR questionnaires. Together participants joined a remote session in which they listened to conversational speech in realistic "restaurant" background noise at various SNRs. Both listened to hearing loss simulations and watched a video which portrayed empathy and third-party disability. Finally, the client and partner participated in a structured exit interview, discussed their mismatches, developed mutual goals toward improving general communication, and then repeated the same questionnaires. The structured interviews were analyzed using a qualitative approach to evaluate common social and emotional experiences of adults with hearing loss and their significant partners.

Results: Preliminary analysis of structured interviews revealed themes around experiences with audiologists, satisfaction with hearing aids, effort, self-advocacy, emotional experiences of hearing loss,

and grief related to hearing loss. Similar to past quantitative analysis, qualitative analysis of structured interviews revealed variable experiences across couples. Partners shared communication strategies that have developed organically in their partnerships. Communication strategies already in use by clients and partners mirror those generally recommended in audiology. Clients and partners expressed appreciation of the hearing loss simulation as a method of increasing empathy. Preliminary results suggest that experiences with audiologists and with hearing devices vary widely, ranging from very negative to very positive.

Conclusions: Many clients have organically developed strong self-advocacy skills that they use in daily life. Strong self-advocacy skills, however, did not always translate to fewer feelings of frustration or grief regarding hearing loss. Clients and partners intuitively understand that communication is not the sole responsibility of the person with hearing loss, as they report accommodations they make to their listening situations. When prompted, partners were able to identify goals that could improve or support their communication strategies. Similar to findings from other research groups, hearing aids were discussed as one of a variety of communication tools rather than as the primary focus of their hearing and communication needs.

Category: Hearing Loss / Rehabilitation

Poster #: 186

Comparing Measures of Hearing and Hospitalizations: The ARIC Study

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Objectives: Hearing loss (HL) is a prevalent condition among older adults and is associated with increased hospitalization utilization. While the majority of the literature relies on self-reported hearing and pure-tone audiometry, the underlying construct of hearing loss might not be fully captured as it contains multiple domains. This study aimed to investigate different measurements of hearing by comparing their associations with hospital utilization. We hypothesized that for all measures of hearing, worse hearing would be related to increased hospitalization utilization.

Design: Analyses utilized cross-sectional data from the Atherosclerosis Risk in Communities study (2016) and linked Centers for Medicare and Medicaid Services (CMS) records. Hearing was measured using (1) 4-frequency (0.5/1/2/4 kHz) pure-tone audiometry (none, ≤25 dB HL; mild, 26-40 dB HL; moderate/greater, >40 dB HL), (2) the Audibility Index (AI), (3) the Quick Speech-in-Noise (QuickSIN) test, and (4) the Simplified Hearing Handicap Inventory for the Elderly (HHIE-S). Hospitalization outcomes (ascertained from CMS claims) included occurrence of any hospital stays and number and duration of hospital stays. Zero-inflated Poisson models were used to examine associations of hearing

measures with occurrence and count of hospital stays. Multilevel mixed-effect negative binomial models were used for length of stay of all inpatient hospitalizations. All models were adjusted for demographic, socioeconomic, and health characteristics.

Results: The sample consisted of 1330 older adults (Mean age=79.3 years; Female=57.8%; Black=17.4%). Relative to those without HL, those with mild and moderate/greater HL had 1.71 (95% Confidence Interval [CI]=1.13-2.58) and 1.87 (95% CI=1.18-2.98) times higher prevalence of any hospital stay over 12 months; 2.23 (95% CI=1.47-3.37) and 1.68 (95% CI=1.04-2.71) times higher incidence rates of multiple hospital stays; and 2.41 (95% CI=1.46-3.98) and 2.32 (95% CI=1.32-4.07) times higher incidence rates of longer overnight inpatient admissions, respectively. Compared to those in the highest tertile of AI scores, those in the second and first tertiles had 1.47 (95% CI=0.98-2.21) and 1.72 (95% CI=1.12-2.66) times higher prevalence for any hospital stay over 12 months; 2.05 (95% CI=1.34-3.12) and 1.58 (95% CI=1.01-2.49) times higher incidence rates of multiple hospital stays; and 1.86 (95% CI=1.11-3.13) and 2.08 (95% CI=1.19-3.64) times higher incidence rates of longer overnight inpatient admissions, respectively. Associations between QuickSIN and HHIE-S scores across all outcomes were not statistically significant.

Conclusions: The QuickSIN and HHIE-S were not comparable hearing measures to PTA, perhaps due to their measurement of different aspects of hearing compared to PTA (peripheral hearing versus central auditory information processing). While the AI corresponded well with PTA, this may be due to the AI being derived from PTA. Further work should focus on the comparison of other hearing measures against healthcare outcomes to explore the use of more accessible hearing measures in the field.

Category: Hearing Loss / Rehabilitation

Poster #: 187

Predicting Spoken Lexical Development in D/HH Children

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Objectives: Infants with hearing loss are at risk for delays in spoken language acquisition. Although the use of hearing aids and cochlear implants positively affect their spoken language development, there is great variation in spoken language outcomes within this group of children. Relatively little is known about the factors that may mitigate spoken language delays. As a result, early intervention can at present not be sufficiently tailored to the individual's language skills and trajectory. To help optimize future interventions, we here aim to develop an early speech perception measure to reliably predict later spoken language competence. More specifically, this study will establish if and when infants with hearing loss acquire two fundamental aspects of spoken language processing: early phoneme discrimination and later word comprehension. We hypothesize that there is a predictive relationship between these two abilities in D/HH children, that may be modulated by visual speech cues.

Design: We investigate (1) native auditory phoneme discrimination (APD) in the presence and absence of visual cues using the hybrid visual habituation procedure and (2) lexical processing efficiency (LPE) with the gaze-triggered looking-while-listening paradigm, in infants with (n=12) and without (n=24) hearing loss at three time points. Infants participate in an eye-tracking experiment testing APD at both 6- and 10-months hearing age (measured from hearing aid fitting and/or cochlear implantation) and another eye-tracking experiment testing LPE at 10- and 14-months hearing age. Additionally, we assess infants' vocabulary and speech perception and production performance through parental completion of validated questionnaires. Because the experiments are conducted in participants' own homes, the burden on parents' time and energy is minimized.

Results: Preliminary results will be presented since data collection is still ongoing. We will analyze the developmental relationship between APD and LPE and determine whether this relationship is modulated by visual speech cues. A relationship between APD and LPE in D/HH children would enable us to improve diagnostic procedures monitoring language development before the age of two. If the relationship is modulated by visual speech cues, this will inform treatment recommendations.

Conclusions: The insights gained from this project will strengthen diagnostic procedures for assessing spoken language processing in deaf and hard-of-hearing infants after hearing aid fitting and/or cochlear implantation that are used by audiological centers, cochlear implant teams, and centers for early intervention. This will ultimately benefit early intervention for DHH children.

Category: Hearing Loss / Rehabilitation

Poster #: 188

Audiologists' Values in Hearing Healthcare

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Objectives: Consumers prefer products and services that align with their values. A misalignment of patient values with the values enacted in hearing healthcare may be a causal factor in the ongoing epidemic of untreated hearing loss in the United States. As the primary provider of clinical services, audiologists largely determine the values enacted in hearing healthcare. In a previous study, we documented the values of audiology by performing a qualitative content analysis of documents representative of traditional, best-practice audiology. However, best-practice documents may not represent the values of practicing audiologists. The objective of this study was to elicit the stated values of audiologists and evaluate the alignment of stated values with documented best-practices.

Design: A values-ranking survey was administered online to audiologists to elicit the prioritization of values from hearing healthcare providers. Respondents were asked to sort and rank a list of 18 items that each exemplified a specific value in order of importance, and to suggest values not included in the list. Survey items were developed based an established codebook of values in hearing healthcare.

Audiologists were primarily recruited from professional association mailing lists. We received 759 total responses. After removal of incomplete or disqualifying responses, data from the 289 U.S.-based audiologists across 46 states were analyzed. Kendall's rank correlation and rank distance tests were used to compare values prioritization between audiologists and best-practice audiology to reveal whether there is a statistically significant correlation among the order of the two lists of values.

Results: The primary result was a list of values in mean rank order of importance among U.S.-based audiologists. The three values ranked most highly by audiologists included accuracy, safety, and equity. Additional values suggested by audiologists were consistent with existing values resulting in no additions to the list of values obtained from best-practice documents. A second objective of this study was to compare the rank order of values in best-practice documents to audiologists' rankings. Despite substantial agreement in high and low priority values, there was no significant correlation between the rank order of values of the two lists.

Conclusions: We validated a comprehensive list of the values of traditional audiology and identified the rank order of values of practicing audiologists. This study will facilitate future work evaluating the role of values in the decision-making processes of people with hearing difficulty. If values conflicts are a barrier to the use of hearing healthcare, potential solutions can be developed that are tailored to the values of specific populations.

Category: Hearing Loss / Rehabilitation

Poster #: 189

Affordability of Hearing Aids for Asian Americans

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Objectives: Few studies have investigated Asian-American's access to hearing health care. The odds reporting of ever undergoing an audiologic evaluation was significantly lower for Asian Americans than for White, African American, or Hispanic Latino groups. One major obstacle for all Americans with hearing loss is the cost of hearing aids. In 2020, the average cost of a hearing aid was $2500. Previous studies found that Asian Americans perceived cost of hearing aids as an obstacle to amplification. It would be important to explore the affordability of hearing aids for Asian Americans and if results would vary as a function of age, living arrangement, sex, education, or geographic region. It is hypothesized that hearing aids are not affordable for some Asian Americans.

Design: Data from the 2020 US Census Bureau American Community Survey was used to determine the proportion of Asian Americans for whom an expenditure of one ($2500) or two ($5000) hearing aid(s) would be unaffordable. The catastrophic approach determined the proportion of the population for which the price of a hearing aid would exceed 3% of annual income. A hearing aid at a price of P was considered unaffordable if P > 3%. The impoverishment approach was used to determine what proportion would fall below the United States Federal Poverty Level (US-FPL) for the year if purchasing hearing aids. Differences on affordability were assessed for age (64 y vs. > 65 y), living arrangement (alone vs. with kids, no adults vs. with adults, no kids vs. with kids, with adults, sex (male vs. female), education (<high school; > high school), and geographic region (midwest vs. northeast vs. south vs. west).

Results: The unweighted sample of Asian Americans with functional hearing loss was N=4618 and the total unweighted sample was N=178,048. The impoverishment approach determined that after a hypothetical purchase of one hearing aids at a cost of $2,500 would result in an additional 20.64% (95%CI 20.52, 20.76) falling below the US FPL for the year. Similarly, the catastrophic approach found that this purchase would exceed 3% of the annual incomes of 57.58% (95%CI, 57.43, 57.73) of Asian-Americans' households. Affordability varied for age, living arrangement, sex, education, and geographic region.

Conclusions: The results indicated that purchase of a single hearing aid was unaffordable for a significant proportion of Asian Americans who may need specific informational counseling about costs of hearing aids and access to groups who may providing funding for those pursuing amplification.

Category: Hearing Loss / Rehabilitation

Poster #: 190

Comparison of Inpatient Satisfaction Measures in Patients with Hearing Loss

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Objectives: The Questionnaire on the Quality of Physician-Patient Interaction (QQPPI) and the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) are tools to measure patients' impressions regarding satisfaction with and quality of healthcare and provider interactions. The QQPPI was originally developed to be used following the provision of outpatient care; the HCAHPS was implemented by the Centers for Medicare and Medicaid Services following inpatient hospital stays.Previous research indicates that individuals with hearing loss (HL) have higher healthcare costs and inpatient stays. These patients are also more likely to rate overall healthcare satisfaction lower. Communication barriers between patients with HL and medical providers may lead to negative

experiences and drive poor healthcare satisfaction ratings. Though dissatisfaction with overall healthcare in individuals who have HL has been well-documented, previous research has not compared these two surveys directly, particularly in a population of older adult inpatients for whom hearing sensitivity was also measured. OBJECTIVES: The purpose of this study was to compare the QQPPI and HCAHPS metrics, including overall scores and descriptive comparisons of the survey questions. Quantitative analyses were performed to investigate the strength of the associations between the patient satisfaction metrics, as well as between hearing loss and average satisfaction scores measured with each survey. It was hypothesized that the scores for the two patient satisfaction surveys would be closely related and that the relationships between patient satisfaction surveys and hearing sensitivity would be of similar magnitude and negative direction.

Design: Screenings of hearing and both patient satisfaction measures were completed with 48 inpatients aged 65 years and older on Medicine units of Johns Hopkins Bayview Medical Center. Additional inclusion criteria required the ability to verbally respond to screening questions presented in English. Bedside hearing screenings were using the iPad-based SHOEBOX audiometry app, and hearing loss was quantified using the pure tone average (PTA) of the better-hearing ear.

Results: Pearson's correlation coefficient for QQPPI and HCAHPS average overall scores was 0.54 ($p>0.0001$), suggesting a statistically significant correlation of moderate strength. Nonsignificant negative correlations were found between the QQPPI (-0.07) and the HCAHPS (-0.19) with the better ear PTA in the unadjusted model. These findings are consistent with previous literature linking increased amounts of HL with poorer patient satisfaction. However, previous research utilized self-reported hearing function, rather than audiometric thresholds. Additional analyses are required to identify variables of impact and determine the true relationship between these metrics and hearing loss severity.

Conclusions: The statistically significant correlation between the surveys shows the coherence in perceptions of healthcare quality across different assessment tools, and the negative correlation between surveys and PTA affirms adverse impacts of HL on satisfaction. By identifying factors that contribute to diminished satisfaction in this demographic, providers can tailor interventions to mitigate the impact of HL on patient experience. Overall, the study serves as an early signal of interest with respect to the assessment of healthcare satisfaction in elderly inpatients with sensory impairments and urges a deeper exploration of the intricate interplay between these variables.

Category: Hearing Loss / Rehabilitation

Poster #: 191

Process Evaluations: Aids in the Creation of Effective Health Interventions

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Objectives: Sometimes researchers develop a treatment that is shown to be effective in the laboratory, but clinicians don't use it because it doesn't fit into their service delivery system. Alternatively, researchers

may think they have developed a great new treatment but cannot determine efficacy because individuals (with the condition) choose not to participate in the research study. Implementation science is the study of procedures to determine the strategies that result in the uptake and use of health interventions in the community. Process evaluations are a vital component as they may determine why an intervention is not taken up and used by clinicians or by potential participants. Process evaluations are used to evaluate public health interventions that are implemented in the community using existing systems to distinguish between interventions that are inherently faulty and those that are poorly delivered (implementation failure). We will describe a process evaluation that was conducted after an effectiveness study of an Internet based Decision Coaching Guide (DCG) to aid older adults in deciding whether to visit an audiologist. Effectiveness studies are conducted in a 'real-world' setting with investigators having no contact with and no payment to potential participants.

Design: For the effectiveness study, we recruited participants from four different arms that varied in terms of trust, cues to action and accessibility to determine how these factors affected rates of uptake and completion of the DCG. We hypothesized that locations with higher trust and cues to action would have higher uptake of the DCG. The four arms included an Optimal Aging Center (high trust, high cue to action), Primary Care Physicians (PCP) offices (high trust, high cue to action), informational lectures in the community (moderate trust, limited cues to action) and Social Media (e.g., Google ads; low trust, low cue to action, high accessibility). In each arm, potential subjects were screened for hearing loss (with the single question: Do you think you have a hearing loss right now?) and given instructions to access the DCG on the internet. Despite 18 months of recruitment and adjustments to the process, only 2 subjects enrolled in the study. Midway through the study the research team began a Process Evaluation to understand the barriers and facilitators that led to these outcomes. We conducted interviews with providers and staff at study locations, with participants, and with social media marketing experts. Google analytics were analyzed for virtual recruitment methods and tracking outcomes after making changes to study landing pages. Finally, electronic medical records (EMR) were analyzed to determine the impact recruitment efforts had on provider referrals to audiology before, during and after the study period.

Results: Our findings suggest that the cue to action from trusted providers, e.g., PCPs, were strong enough for potential participants to skip the DCG and make an appointment with audiology. However, in other cases the trusted provider did not recommend use of the DCG or audiology.

Conclusions: Study results and previously published research will be reviewed to guide the uptake of internet-based treatments in the future.

Category: Hearing Loss / Rehabilitation

Poster #: 192

Hearing Aid Success in Individuals with High Hearing Aid Self-Efficacy

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Objectives: Hearing aid self-efficacy (HASE) is a patient attribute that has been demonstrated to impact aspects of hearing aid (HA) success and can also be directly targeted in audiologic rehabilitation. Having

said that, it remains unclear how clinicians should capitalize on HASE improvements to optimize HA outcomes. One step towards shedding light on this issue is to seek out individuals who have high HASE and are successful HA users, and use qualitative research methods to explore their perceptions of their hearing health care journeys, including how they overcame barriers to their success. Understanding their shared experiences as they navigate their journey toward successful HA use could illuminate the resources related to HASE that systematically facilitated positive outcomes. If such similarities exist, clinicians could use this knowledge to design interventions that might mimic these resources for other HA users. This study aimed to identify the shared resources or facilitators that they experienced which might have resulted in or from having high HASE and contributed to their ultimate success with HAs.

Design: A purposeful sample of 5 experienced HA users with high HASE and high HA satisfaction were recruited. These participants were older adults aged 66 to 83 years (2 females). An interpretive phenomenological qualitative approach was used for data collection and analyses. In one appointment, data collection was completed using semi-structured in-depth interviews. Interview questions were structured around the transtheoretical model of behavior change. Secondary prompts and follow-up questions were used as needed to clarify responses. Interview transcripts were analyzed using thematic and holistic analyses. Interpretive summaries were generated using the transtheoretical model. In a second appointment, these summaries were verified with the participants.

Results: All participants reported experiencing barriers to HA success at each stage of their hearing health journey. However, they could overcome these barriers and become successful HA users. The factors that were most important from these participants' perspectives, and that were shared among the group, were inherent or learned personal characteristics and qualities that they relied on to overcome barriers to their long-term success. Six different themes emerged as facilitators towards their success. Participants attributed their success to having (1) intrinsic motivation to improve their hearing; (2) confident self-reliance when making health decisions, (3) openness to acting on considered advice from trusted others, (4) having pro-social personal attributes, (5) having positive expectations about HA outcomes, and (6) taking an active role in pursuing optimal outcomes with their hearing.

Conclusions: Most of the shared experiences of our participants indicated that the keys to their success with HAs were inherent characteristics such as personality and level of motivation. This suggests that a specific combination of inherent characteristics underlying HASE, rather than specific external experiences, might be the driving factors behind these individuals' hearing aid success. Thus, although HASE might be modifiable through direct intervention, such external influences could be less likely to result in measurable changes in HA outcomes than previously assumed. However, more research is warranted to fully understand the mediating role of self-efficacy-based rehabilitation on HA success.

Category: Hearing Loss / Rehabilitation

Poster #: 193

That Looks Noisy: An Image-Based Questionnaire (IBQ) for Assessing Self-Reported Hearing

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Objectives: To develop an 'Image-based hearing questionnaire' (IBQ), in which written descriptions of a listening situation (e.g. 'Having a conversation with several people in a group') are replaced by a photograph depicting that scenario. The fourteen scenarios defined by the Common Sound Scenarios (CoSS) framework were chosen for use in the IBQ.

Design: The IBQ was developed in 3 steps. Step 1. Patient and Public Involvement, Engagement and Participation (PPIEP) focus group. Seven members of the public provided their views about the concept of an IBQ, and the meta-content of images to use (i.e. factors pertaining to age, ethnicity and gender of individuals in selected photographs). Step 2. Initial selection of images. Using insights from the PPIEP activity, six iStock images were selected for each of the 14 CoSS scenarios (84 images total). Seventy-one participants (Age: Mean=52.3, SD=19.2, range=21-85; Female=49%, 30% poor reported hearing) were shown the 14 sets of six images for each CoSS scenario. They rated how well they thought they would hear if they were in each scenario, and indicated which of the six images (if any) best represented each specified CoSS scenario. The two most-selected images for each CoSS scenario (a total of 28 images) were used in Step 3. Step 3. Validation of selected images: For each of the 28 images, participants (n=42; Age: Mean=65.1, SD=12.7, range=33-86; Female=50%, 48% poor reported hearing) wrote a sentence describing what they thought they would be listening to/trying to hear if they were in the scenario shown, and rated how well they thought they would hear in that scenario.

Results: PPIEP panel members said an IBQ would avoid the need for questionnaire translation and problems with interpreting written statements that happens with standard questionnaires; that an image-based response scale should be used; and that the age, sex and ethnicity of individuals in particular photographs is unimportant if there is a mix within the questionnaire as a whole. The hearing ratings (steps 2 and 3) support the hypothesis that people can judge a listening situation from a photograph in that ratings were significantly lower (hearing more difficult) for scenes depicting (i) noisy scenarios than quiet scenarios, (ii) group interactions than one-on-one interactions, and (iii) live sounds than sounds presented through a device (i.e. with a volume control). Content analysis of the open-ended descriptions of the photographs (Step 3) indicated that participants interpreted the images according to each listening scenario. That is, singular nouns were used to describe images depicting one-on-one scenarios, plural nouns were used for group scenarios, the word 'trying' or 'noise' was commonly used when describing images of noisy places, direct mention of a device was made (e.g. telephone, television) in scenarios depicting those devices.

Conclusions: The IBQ could be a valuable self-report measure of hearing because it is language-independent and reading-free. Furthermore, responses might be less influenced by individual interpretation than when answering a standard written questionnaire. We are now examining associations between IBQ scores, measured hearing, and self-reported hearing assessed with a standard questionnaire.

Category: Hearing Loss / Rehabilitation

Poster #: 194

Multisensory Loss and Depression in the Atherosclerosis Risk in Communities Neurocognitive Study

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Objectives: The prevalence of depressive symptoms in older adults is approximately 10% in the United States. Depressive symptoms can lead to the debilitation of mental and physical well-being. Multisensory loss is a potentially modifiable risk factor for depression; however, there is a lack of population-level evidence assessing the association of multisensory loss with depressive symptoms. This study quantified the cross-sectional association of multisensory loss across four senses (hearing, vision, olfaction, and touch) with depressive symptoms in older community-dwelling adults.

Design: Data were from the Atherosclerosis Risk in Communities Study (ARIC) 2016-17 Visit 6 and the Eye Determinants of Cognition (EyeDOC) ancillary study joint cohort, an observational study of older adults from Washington County, MD and Jackson, MS. The analytic sample for this cross-sectional analysis included 812 participants with complete data on hearing, vision, olfaction, peripheral neuropathy, depression, and demographic and health covariates. Depressive symptoms were measured using the 11-item Center for Epidemiologic Studies Depression (CES-D-11) scale. CES-D-11 scores were modeled continuously. The better-hearing ear with a 4-frequency pure-tone average (PTA) in decibels hearing level (dB HL) was measured at 0.5, 1, 2, and 4 kHz. Levels of hearing loss were defined by the World Health Organization (WHO) guideline as normal and mild (<35 dB HL) and moderate or greater (≥35 dB HL) hearing loss. Vision loss was defined as having any dysfunction in presenting visual acuity using the Early Treatment of Diabetic Retinopathy Study (ETDRS) chart. Impaired visual acuity was defined as worse than 20/40 (log of the minimum angle of resolution (logMAR) units > 0.3). Olfaction was measured using the 12-item Sniffin's Sticks Odor Identification Test; olfactory impairment was defined as a score ≤ 8. Peripheral neuropathy using a 10g monofilament test; loss of peripheral neuropathy was defined as at least one insensate site on either foot. Multisensory loss was analyzed as a count (0-4). Ratio of depressive symptoms associated with number of sensory losses was assessed using covariate adjusted negative binomial regression. Covariates include age, sex, race/ethnicity, education, BMI, smoking, diabetes, hypertension, stroke, alcohol consumption, and chronic kidney disease.

Results: Of 812 participants (aged 71-93 years, 62.7% female, 58.6% White, 43.3% with higher than a high school education), 30.3% had one sensory loss, 31.4% had two, 17.6% had three, and 5.3% had four. Each additional sensory loss was associated with a 10% (Risk ratio of CES-D-11 Score: 1.10; 95% CI: 1.02-1.20) greater CES-D-11 score in the fully adjusted model.

Conclusions: Multisensory loss is associated with depressive symptoms in older adults. Clinical awareness of this association is valuable for promotion of mental well-being among older adults with sensory loss.

Category: Hearing Loss / Rehabilitation

Poster #: 195

Needs and Wants: Subjective Intelligibility and Criteria Affecting Noise Tolerance

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Objectives: The Tracking of Noise Tolerance (TNT) test is a Békésy-tracking noise acceptance measure developed to evaluate hearing aid feature efficacy. Over the years, TNT studies have revealed notable variability in overall noise acceptance and patterns of noise tracking in both normal hearing (NH) and hearing-impaired (HI) older adults. Recently, the Noise Tolerance Domains Test (NTDT) was used to study which of four subjective noise domain criteria (speech interference, loudness, annoyance, and distraction) are weighted most heavily by younger NH listeners when judging noise acceptance. Here, we use the NTDT to examine how different older NH and HI listeners weigh the same four domain criteria when performing the TNT. We further integrate NTDT results with estimates of subjective intelligibility for the TNT speech materials across a range of signal-to-noise ratios (SNRs) covering the average excursion of tracked noise levels.

Design: Twenty-two NH and 17 HI older adults performed the TNT to determine average noise acceptance thresholds (TNTAve). Listeners then provided estimates of subjective intelligibility for TNT materials at different SNRs to produce subjective psychometric intelligibility functions. Finally, listeners completed the NTDT at SNRs of -3, 0, and +3 dB relative to their TNTAve scores. The NTDT presented TNT materials and required that listeners (1) select which of two domain criteria (e.g., distraction and speech interference) was "most responsible for their non-acceptance of noise" and (2) weigh the influence of all four domain criteria on a scale of 0–100. The proportion that a particular domain was chosen, multiplied by the average weight assigned to that domain, defined its Weighted Noise Tolerance Domain Rating (WNTDR). All tests were conducted with speech input levels of 75 and 82 dB SPL, presented front the front in sound field with co-located speech-shaped noise. Both NH and HI listeners were tested in the unaided mode; HI listeners were also tested using a study hearing aid.

Results: WNTDRs were affected by listeners' estimated subjective intelligibilities across test SNRs, regardless of their hearing status (NH/HI), given sufficient in-situ acoustics. When subjective intelligibility was poor, the domains of speech interference and loudness were weighted most heavily. As subjective intelligibility improved, weightings shifted toward annoyance and distraction. Based on the most heavily weighted domain at TNTAve, it was determined that that listeners could be broadly categorized into those prioritizing acoustic factors or 'needs' (speech interference and loudness) and those prioritizing emotional/cognitive factors or 'wants' (annoyance and distraction). General linear regression further determined that subjective intelligibility at TNTAve best accounted for category membership, over listener demographics, TNT performance outcomes, or subjective intelligibility reception thresholds.

Conclusions: All listeners are instructed to perform the TNT such that they maintain the loudest level of noise they can "put up with" while understanding > 90% of speech. However, these results suggest that listeners may follow two broadly different strategies, one in which noise tolerance is defined by the perception of acoustic interference and the other in which it is defined by emotional/cognitive judgements made at SNRs where acoustic needs are already satisfied.

Category: Hearing Loss / Rehabilitation

Poster #: 196

Randomized Controlled Trial Methodology to Examine Unilateral vs Bilateral Fittings

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Objectives: Millions of Americans suffer from age-related hearing loss (ARHL). Population estimates for hearing loss severity as a function of age indicate that 10.5% of adults in their 50s have mild hearing loss bilaterally and this estimate increases to 36% for those ≥80 years. The estimates for those with moderate bilateral hearing loss range from 2.1% for those in their 50s to 37.9% for those ≥80 years. Hearing aids are the primary treatment option for ARHL, and practice guidelines, most audiologists advocate for bilateral hearing aids for the vast majority of patients. Even though ARHL presents most often as symmetrical and bilateral, there currently is no convincing evidence to support the recommendation of bilateral hearing aids over a unilateral hearing aid. In addition, there is no clinical outcome evidence to guide patients in their decisions to purchase one or two hearing aids nor is there a clear understanding of the personal values or factors that predict outcomes in general, let alone, to guide choices regarding one or two hearing aids. Thus, our overarching study goal is to determine the relative benefit of unilateral or bilateral hearing aid fittings in the treatment of mild-to-moderate ARHL in individuals 50+ years of age.

Design: To accomplish this study goal, we will use a randomized controlled trial with two treatment arms including: (1) a bilateral hearing aid fitting group, and (2) a unilateral hearing aid fitting group. All participants (N = 266) will be administered baseline (unaided) and 3-month post-intervention (aided) measures to assess both performance and patient-reported outcomes with their assigned hearing aid fitting configuration. The primary outcome is the change in hearing difficulty as measured by the Abbreviated Profile of Hearing Aid Benefit. At 3 months, patients have an opportunity to choose their hearing aid fitting configuration (0, 1, or 2 hearing aids) and we will monitor their final outcomes using their hearing aid configuration of choice for another 3 months using patient-reported outcome measures. A subset of patients will also participate in a focus group to better understand their experiences with one or two hearing aids, and their decision about their hearing aid choice at 3 months. Study patients pay for

their devices and services, albeit at a discounted rate, and have a 6-month trial period as part of the study.

Results: This presentation will focus on our methodology of an ongoing trial, and not results are presented. Our primary hypothesis is that patients with mild to moderate hearing loss will find bilateral hearing amplification to be more beneficial (primary outcome via Abbreviated Profile of Hearing Aid Benefit) after 3 months. In addition, we also want to determine the factors associated with patient choice of hearing aid fitting configuration (either unilateral or bilateral).

Conclusions: This presentation will describe how we used mixed methods to answer the research questions. We will also describe the contribution of a community advisory team (patients with ARHL, care partners, audiologists, ENTs, primary care, and industry) to the overall study.

Category: Hearing Loss / Rehabilitation

Poster #: 197

All the Buzz: Enhancing Tinnitus Rehabilitation Services Through Patient Narratives

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Objectives: Tinnitus is a prevalent and sometimes debilitating condition among Veterans and is currently ranked as the most frequently diagnosed service-connected disability. Veterans' experiences with bothersome tinnitus are varied and complex due to common comorbidities, so restoring function and quality of life involve individualized management plans. Currently available instruments to evaluate the impact of tinnitus are limited in their ability to capture the functional impact of tinnitus on an individual. There is evidence demonstrating that viewing other patients' video narratives on the lived experience of managing chronic health conditions is efficacious for patients. The objective of this study was to document Veteran narratives on bothersome tinnitus and establish the methodological and technical feasibility of building a prototype video module. As part of a larger mixed methods study, we present our findings on patients' narratives on living and coping with bothersome tinnitus.

Design: Leveraging an administrative data pull of Veterans' medical records and maximum sampling strategy, we identified and interviewed 13 Veterans (Mean Age= 61 years; SD= 14.6 years; Male= 46%; Female= 54%) who experienced bothersome tinnitus. Of the interviewees, 54% (n=7) identified as Hispanic or Latino/a and 46% (n=6) identified as not Hispanic or Latino. With respect to race, 38% (n=5) of interviewees identified as White, 31% (n=4) identified as Black, 15% (n=2) identified as Other, 8% (n=1) identified as Hawaiian, and 8% (n=1) identified as multiracial. These interviews were conducted virtually using the DIPEx (Database of Individual Patient Experiences) methodology, a tool for documenting patient narratives.

Results: The collected narratives covered many issues related to living with tinnitus. For this poster, we report on themes related to: (a) coping, (b) challenges with providers, (c) managing tinnitus and other chronic conditions, and (d) the reported benefit of hearing stories from other Veterans. Each narrative highlighted unique approaches to coping, and Veterans shared stories of navigating a balance between avoiding activities they cannot tolerate, while still managing to engage in meaningful ones. Initially, several Veterans believed the only solution was to quiet their tinnitus. However, over time, they learned strategies to improve their well-being that did not necessarily entail reducing the actual sound of tinnitus. Some Veterans reported feeling as though their providers were not knowledgeable about tinnitus and unable to provide them with individualized management. Veterans also shared stories about managing tinnitus alongside other chronic conditions such as anxiety, PTSD, and TBI. Overwhelmingly, Veterans in our sample endorsed the value of hearing stories from others as a useful rehabilitative resource to find hope and learn coping strategies.

Conclusions: Our preliminary data indicate that Veterans with bothersome tinnitus find therapeutic value engaging with the narratives of others experiencing tinnitus. Our investigation also established the methodological feasibility of using a maximum sampling strategy and DIPEx to systematically collect narratives from patients with bothersome tinnitus and confirmed the technical feasibility of building the prototype module. Our initial efforts to develop narrative modules offer a promising development toward a holistic approach to tinnitus care that addresses not only the physical aspects but also the emotional and psychological dimensions.

Category: Hearing Loss / Rehabilitation

Poster #: 198

Hearing Loss and Hospitalization: The Atherosclerosis Risk in Communities Study

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Objectives: Hearing loss is a pervasive condition among older adults that is associated with increased use of hospital inpatient services. This study aims to investigate the association between objectively measured hearing loss and claim-based use of hospital inpatient services in a population-based sample. We hypothesized that greater hearing loss would be related to increased use of hospital inpatient services.

Design: Analyses utilized cross-sectional data from the Visit 6 of the Atherosclerosis Risk in Communities study (2016) and linked Centers for Medicare and Medicaid Services (CMS) records. Participants were recruited from Forsyth County, North Carolina, Jackson, Mississippi, suburbs in Minneapolis, Minnesota, and Washington County, Maryland. Hearing loss was assessed based on four-frequency (0.5/1/2/4 kHz) pure-tone average for the better-hearing ear, with hearing loss categorized as no hearing loss (≤25 dB HL), mild hearing loss (26-40 dB HL), and moderate/greater hearing loss (>40 dB HL). Hospitalization outcomes (obtained from CMS records) included (1) occurrence of any hospital stays within the past 12 months (yes/no), (2) number of hospital stays, and (3) duration of all hospital stays. Zero-inflated Poisson regression models were used to examine the association of hearing loss with the occurrence and count of hospital stays. Multilevel mixed-effect negative binomial regression models were used for length of stay of all hospitalizations. All models were adjusted for demographic, socioeconomic, and health characteristics.

Results: The sample consisted of 1,330 older adults (Mean age: 79.3 years; Female: 57.8%; Black: 17.4%). Relative to those without hearing loss, those with mild and moderate/greater hearing loss had 1.71 (95% Confidence Interval [CI]=1.13-2.58) and 1.87 (95% CI=1.18-2.98) times higher prevalence of any hospital stay within the past 12 months; and 2.23 (95% CI=1.47-3.37) and 1.68 (95% CI=1.04-2.71) times higher incident rates of multiple hospital stays, respectively. Moreover, both groups had significantly longer durations of hospital stays (Mild: Incident Rate Ratio [IRR]=2.41; 95% CI=1.46-3.98; Moderate/greater: IRR=2.32; 95% CI=1.32-4.07).

Conclusions: Compared to older adults without hearing loss, those with mild and moderate hearing loss had higher prevalence rates of any hospital stay within the past 12 months and higher incidence rates of both multiple hospital stays and longer duration of hospital stays. Our findings confirm previous evidence of the association between hearing loss and use of hospital inpatient services using data from a population-based sample of older adults in the US. Future work should focus on incorporating accommodations for hearing loss to optimize and reduce healthcare utilization as well as designing equitable healthcare systems that meet the needs of all older adults.

Category: Hearing Loss / Rehabilitation

Poster #: 199

Attitudes on Safe Listening at Venues/Events with Loud Music

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Objectives: Noise exposure is the most common cause of preventable hearing loss among U.S. adults. Amplified music is one of the most widespread sources of non-occupational noise exposure. This study surveyed a nationally-representative sample of U.S. adults to assess their willingness to take hearing protective actions at entertainment venues and events featuring loud music.

Design: The 2022 Porter Novelli FallStyles Survey asked a nationally-representative internet panel of 4,514 U.S adults aged 18 years and older about their perceptions regarding hearing loss prevention when exposed to loud music at venues and events. Participants were sampled from the Ipsos KnowledgePanel¬Æ - a probability-based online panel of approximately 60,000 members representative of the non-institutionalized U.S. population. KnowledgePanel¬Æ members are recruited through probability-based address sampling and are provided with a laptop or tablet and internet access if needed. Using a 5-point Likert scale, survey respondents indicated their level of agreement with limiting sound levels to reduce risk, posting warning signs to indicate risk, and wearing hearing protection devices if provided. Data were weighted to the March 2021 supplement of the U.S. Current Population Survey proportions for gender x age, household income, race and ethnicity, household size, educational attainment, U.S. Census Bureau region, and metropolitan residency status.

Results: The survey response rate was 78.1%, resulting in data from 3,526 panelists. Respondents were nearly equally distributed by gender (50.9% female) and were mostly non-Hispanic white (62.8%). Results indicated that 54% of U.S. adults agreed with limiting sound levels, 75% agreed with posting warning signs, and 61% agreed that they would use hearing protection if provided. After adjusting for multiple covariates, agreement was generally higher among women and older adults and increased with educational level. Black adults (regardless of ethnicity) agreed significantly less often with limiting sound levels. Hispanic adults agreed significantly more often that warning signs should be displayed, as did respondents in the lowest (<$25,000) and highest (>$150,000) income categories. Geographic region and metropolitan residency status made little difference in perceptions regarding safe listening to amplified music at venues and events, except that adults in metropolitan areas agreed significantly more often that warning signs should be posted.

Conclusions: Hearing loss from loud music is entirely preventable. U.S. adults appear open to taking hearing protective actions when attending entertainment venues and events featuring amplified music. Health care practitioners can help persons understand their risks from high sound levels and appropriately manage their exposures to avoid hearing damage while still enjoying music. Resources are readily available from government and professional associations to assist with raising awareness of noise risks and promoting protective behaviors.

Category: Hearing Loss / Rehabilitation

Poster #: 200

Predicting Hearing Aid Benefit Using the Audible Contrast Threshold Test

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Objectives: Hearing aids are typically fit using an audiogram-based prescriptive method developed based on speech perception in quiet, though listening in noise remains a primary complaint of hearing aid users. Recent developments in audiology have seen an increase in the complexity and variety of approaches to improve listening in noise, but this shift presents its own set of challenges as the traditional audiogram provides limited information about suprathreshold abilities that are important to understanding speech in noise. There are no evidence-based tools available to customize advanced hearing-aid directionality and noise reduction (DIR+NR) settings. This study aims to validate the Audible Contrast Threshold (ACT) test as a tool to improve the first fit of hearing aids in terms of directionality and noise reduction. We build upon related studies in Japanese- and German-speaking civilian populations by focusing on English-speaking US veterans, a group likely to experience suprathreshold auditory impacts from noise or blast exposure. We hypothesize that the ACT test can serve as an effective measure of suprathreshold ability that correlates with the speech recognition benefits expected from hearing-aid noise management algorithms.

Design: We intend to gather data from 100 US veterans who received an Oticon More or Real hearing aids six to eight months before enrollment in the study. We employ the ACT test which is a clinical measure of spectro-temporal modulation detection using a 4-Hz temporal rate, 2 cycles/octave spectral density, and 354-2000 Hz frequency range. These specific parameters have been previously shown to predict speech reception performance and DIR+NR effects in other populations. We assess the auditory and cognitive abilities of the participants and measure speech-in-noise recognition using a spatial version of the Hearing In Noise Test (HINT) in several DIR+NR configurations: None, Mild, Moderate, or Strong.

Results: Initial results will be presented from all tests, with regression analyses identifying the extent of variability in HINT speech reception thresholds that can be explained by variability in the ACT. Comparisons will be made across noise management settings to determine how differences in speech recognition benefit in noise align with spectro-temporal modulation processing abilities. Demographic and cognitive factors will be included in analyses to tease apart central and peripheral contributions to participant performance.

Conclusions: This research explores a potential tool to aid in the customization of hearing aids for US veterans, a population whose auditory abilities may not be adequately represented by traditional audiological methods. By investigating the alignment between ACT test data and variations in speech recognition in different noise conditions, we seek to provide a foundation for a more comprehensive and individualized approach towards hearing-aid customization in audiology. These findings might lead to optimized first fits with improved listening in noise and enhanced quality of life for people with hearing loss. This research is funded through the Portland VA Research Foundation by a grant from the William Demant Foundation.

Category: Hearing Loss / Rehabilitation

Poster #: 201

Audibility Index and Associations with Dementia in the ARIC Study

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Objectives: Dementia is a public health concern, with the prevalence projected to triple worldwide by 2050. One potentially modifiable risk factor for dementia is hearing loss (HL), with recent randomized trial evidence suggesting hearing treatment may benefit some older adults. Current epidemiologic studies of HL and dementia often rely on speech-frequency pure tone averages (PTA) to define HL; however, this does not necessarily capture clinically relevant data such as potential access to speech (i.e., shape of the audiogram). One easily calculable measure that does is the audibility index (AI), which uses pure tone thresholds and weights frequencies to predict audibility. Because the AI uses equivalent information to PTAs, it can routinely be collected from hearing assessments in large studies with limited time. Whether the AI, which should convey more information than PTA, better predicts functional outcomes in older adults is unknown. In this study, we investigated the criterion and construct validity of the AI by quantifying associations with incident dementia and compared it with other hearing measures we expect to be correlated.

Design: The Atherosclerosis Risk in Communities (ARIC) study is a longitudinal cohort study that recruited adults aged 45-64 (n=15,792) from four communities in the US in 1987-1989. We used audiometric thresholds (0.5-8.0 kHz), neurocognitive measures, and covariate data from ARIC visit 6 (2016-2017; analytic sample, n=2,992). The better hearing ear AI (bAI) was calculated based on five frequencies (0.25, 0.5, 1, 2, 4 kHz) and modeled categorically in tertiles. The better-ear PTA (bPTA) was calculated based on four speech frequencies (0.5, 1, 2, 4 kHz). Incident dementia was defined using a standardized algorithm incorporating expert adjudication. We used Cox proportional hazards models to estimate hazard ratios (HR) of dementia by bAI tertile and by bPTA tertile. Correlations between the bAI and other hearing measures (bPTA, better-ear self-report) were explored graphically.

Results: Among eligible participants (mean age: 74.9 years [range=72-94 years]), relative to the highest tertiles, participants in the lowest bAI tertile were more likely to be older (mean, 76.8 years), male (51.9%), and report hearing aid use (49.1%). Over a median follow-up of 6.6 years, there were 362 incident dementia cases. HL defined by bAI was associated with an increased risk of dementia (second tertile, HR=1.48 [95% CI: 1.13-1.93]; lowest, HR=1.59 [95% CI: 1.21=2.09]). The magnitude of the

association with dementia was similar when HL was defined by bPTA tertile (second tertile, HR=1.37 [95% CI: 1.05-1.79]; highest, HR=1.59 [95% CI: 1.21-2.08]). The bAI demonstrated strong correlation with the bPTA, and weak associations with better-ear self-report.

Conclusions: In a community-based cohort of older adults, HL defined by AI was associated with increased risk of dementia. Inferences were consistent when HL was defined by similar PTA thresholds, likely because AI and PTA were highly correlated. This indicates that the AI derives similar value to PTA while considering potential functional impacts of HL that PTA does not, supporting the use of AI in epidemiologic studies.

Category: Hearing Loss / Rehabilitation

Poster #: 202

Filtering and Congruence Effect Emotional Perception of Audiovisual Stimuli

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Objectives: Adults with hearing loss tend to have more neutral responses to auditory and audiovisual stimuli compared to peers with normal hearing. Low- and high-pass filtering (800 and 2000 Hz, respectively) have been shown to reduce valence (pleasant vs. unpleasant) responses in a similar way, which suggests that high and low frequencies provide useful spectral context that influences emotional responses. One purpose of this study was to examine the importance of mid-frequencies to emotion perception by applying a bandpass filter (800-2000 Hz) to non-speech sounds. A second purpose of this study was to evaluate the interaction between multisensory congruency and filtering. For audiovisual stimuli, it is unclear what effect filtering may have when visual and auditory components are in opposition (e.g. unpleasant sound with pleasant picture). Unpleasant components typically dominate the resulting emotional response, making the audiovisual stimuli unpleasant overall. However, as filtering may make the unpleasant sound less unpleasant, the pleasant visual component may be less effected (i.e., the audiovisual stimuli will be neutral or pleasant). The results of this study have implications for understanding mechanisms that might explain emotion perception for adults with hearing loss and for understanding the relative dominance of audition and vision on emotion perception.

Design: Twenty adults with normal hearing (recruited via word of mouth) were presented with a series of non-speech auditory and audiovisual stimuli and were asked to rate each stimulus in the dimensions of valence and arousal (exciting vs. calming). Auditory stimuli were presented unfiltered or bandpass filtered from 800-2000 Hz, and were sometimes combined with either a visual stimulus of congruent valence (e.g., pleasant sound with pleasant picture) or incongruent valence (e.g. pleasant sound with unpleasant picture). Participants made ratings in six stimulus modalities: auditory-only, filtered auditory-only, congruent audiovisual, incongruent audiovisual, filtered congruent audiovisual, and filtered incongruent audiovisual.

Results: Linear mixed-effects modeling revealed responses to incongruent stimuli were dominated by the unpleasant stimuli; unpleasant sounds with pleasant pictures or vice versa resulted in more unpleasant ratings. Also, bandpass filtering auditory-only stimuli effectively reduced the range of valence responses (less pleasant and less unpleasant). When paired with visual stimuli, bandpass filtering only affected unpleasant sounds, resulting in ratings that were less unpleasant in response to filtered than unfiltered stimuli.

Conclusions: Neither audition nor vision seems to dominate incongruent multisensory stimuli; rather, the unpleasant stimulus of either modality dominates emotion perception. Consistent with prior work using low-pass and high-pass filtered stimuli, bandpass filtering results in more neutral responses to auditory and audiovisual stimuli, which is similar to results seen in adults with hearing loss. This suggests that the filtering effects of hearing loss may be responsible for the reduced emotional responses. Previous studies have shown that simply amplifying the sounds in an attempt to counteract the hearing loss can often make the resulting sound more unpleasant, and so creative solutions will need to be developed in order to restore the wider range of emotional responses that a person may have experienced prior to their hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 203

Predictors of Listening Effort Benefits with Directionality and Noise Reduction

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Objectives: Understanding speech in noise could be effortful for hearing aid users. To reduce listening effort, hearing aid technologies, such as directional microphone (DIR) and digital noise reduction (DNR), have been designed and used to improve signal-to-noise ratios (SNR) and listening comfort. Despite demonstrated effects on listening effort, there is still substantial variation in perceived effort among hearing aid users in different listening environments. It is hypothesized that factors pertaining to individuals using hearing aids, such as demographics, audiological data, cognition, self-reported measures of hearing handicap, effort, and fatigue, may influence the assessment of listening effort. The purpose of this study was to explore how these characteristics of listeners relate to benefits of using DIR/DNR under different degrees of aided effort measured using the Adaptive Categorical Listening Effort Scaling (ACALES).

Design: Twenty experienced hearing aid users with symmetrical sensorineural hearing loss wore Starkey Genesis AI 24 RIC RT devices with clinically appropriate couplings. The participants were 42 to 85 years old (Mean=70.4, SD = 10.1). Two hearing aid conditions were tested: (1) DIR/DNR disabled and (2) DIR/DNR enabled. In each condition, listening effort was measured using ACALES. Specifically, English Matrix Test sentences were presented from 0-degree azimuth at various levels in a diffuse noise (ICRA250) at 65 dB SPL. Listening effort was quantified using the SNRs associated with each ACALES rating (ranging from 1-No effort to 13-Extreme effort). In addition, the following potential predictors were collected from each participant: the 36-Item Short Form Health Survey, Cognitive Self Efficacy

Questionnaire II (CSEQ), Revised Hearing Handicap Inventory (RHHI), Vanderbilt Fatigue Scale (VFS), Reading Span Test (RSPAN), Montreal Cognitive Assessment (MoCA), the fatigue assessment scale (FAS), the effort assessment scale (EAS), demographics, and audiological data.

Results: For each of the three listening effort ratings of interest (3-Very little effort; 7-Moderate effort; 11-Very much effort), a linear mixed-effect regression model was used to examine the relationship between the predictors and the listening effort measure in the two hearing aid conditions. The models showed the following significant interaction effects with hearing aid condition ($p < 0.05$): (1) cognition (RSPAN), self-reported fatigue (VFS, FAS), acoustic coupling, and perceived hearing handicap (RHHI) predicted SNR benefit with DIR/DNR in "very little effort" conditions; (2) cognition (RSPAN), self-reported fatigue (FAS), acoustic coupling, and gender predicted SNR benefit with DIR/DNR in "moderate effort" conditions; (3) no variables were found to predict SNR benefit with DIR/DNR in "very much effort" conditions.

Conclusions: The findings of this study suggest that when perceived listening effort is low or moderate, several variables can help predict who benefits most from access to DIR/DNR strategies, including cognition, self-reported fatigue, and acoustic coupling. In contrast, when perceived listening effort is high, DIR/DNR strategies are less effective at providing benefit, in general. This insight can inform study design aimed at assessing listening effort, as well as the development and evaluation of new hearing aid features for reducing listening effort.

Category: Hearing Loss / Rehabilitation

Poster #: 204

Post Noise-Exposure Effects on Genomic and Mitochondrial DNA Integrity

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Objectives: Noise exposure affects 32% of the population in the United States. This wide impact needs attention because emerging studies have suggested that noise exposure can damage auditory organs and non-auditory organs such as the brain, heart, and liver. Indeed, epidemiological studies have found positive associations between noise exposure and increased risk for brain dysfunctions, cardiovascular diseases, and liver dysfunctions. To address these health issues, exploring shared molecular mechanisms impacting different organs would be useful for developing treatments for systemic benefits. DNA damage has been found to be a shared molecular change from noise exposure. A previous study observed DNA damage in the brain, heart, and liver hours after noise exposure; however, the damage returned to normal after a month. Interestingly, this study has only investigated one specific type of DNA nucleotide modification. Many studies have shown that noise exposure could induce other types of DNA damage, such as double-strand breaks. Meanwhile, mitochondrial DNA also shows a high susceptibility to noise exposure. Whether or not those DNA damages could be fully repaired long after noise exposure is unknown. This is highly relevant because the level of DNA damage can be an indicator of overall organ health, and any remaining DNA damage could be a threat to their normal functions. Therefore, this study was designed to investigate the DNA integrity at 30 days after acute noise exposure under the hypothesis that no significant increase in DNA damage in the cochlea, brain, heart, and liver at 30 days post-exposure from the noise-exposed animal relative to that from the control animals.

Design: Long Evans rats have been randomly assigned into the noise (N = 6) or control (N = 6) groups. The noise group was exposed to a 3-hour, 105-dB SPL peak, broadband white noise (12.5 Hz-20 kHz), while the control group was sham-exposed. The noise exposure proved detrimental to the auditory pathway, as indicated by both decreased DPOAE and ABR tests. 30 days after exposure, the cochlea, cortex, heart, and liver were collected. DNA was extracted from each organ and utilized as templates for long-PCR-based DNA damage analysis. This assay works on the principle that DNA templates with DNA damage stall polymerase, resulting in fewer amplicons compared to undamaged DNA templates.

Results: We have found that both genomic and mitochondrial DNA extracted from noise-exposed cochlea generated a greater number of long-DNA amplicons relative to that from the control cochlea. We also found no significant difference in long-DNA amplicons between noise-exposed and control cortex, heart, and liver. These results suggest that 1). DNA integrity improved at 30 days post-noise exposure in the cochlea; 2) DNA integrity returned to normal at 30 days post-noise exposure in the cortex, heart, and liver.

Conclusions: These results indicate a potential upregulation in the global DNA damage repair system within the auditory system following hazardous noise exposure. This may be a protective mechanism of the system, ensuring residual cells are more resilient. However, further studies are necessary to verify and explore the specific repair systems involved in this response.

Category: Hearing Loss / Rehabilitation

Poster #: 205

Evaluation of Medicare Claims-Based Definitions for Hearing Loss

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Objectives: Although existing research relies heavily on administrative and claims data to identify hearing loss, the accuracy of Medicare claims-based definitions for hearing loss is uncertain. We developed and validated prediction models using International Classification of Diseases 10th edition (ICD-10) diagnostic codes to identify older adults with age-related hearing loss against clinical audiometric standards.

Design: We leveraged data from the Atherosclerosis Risk in Communities (ARIC) study linked with Fee-for-Service Medicare claims. The ARIC study is a prospective, community-based cohort study of adults from four US communities. We included all participants aged 65 years and older that underwent a comprehensive hearing assessment at visit 6 (2016-2017) and with continuous Medicare enrollment for at least 12 months between October 1st 2015 to October 1st 2018. We excluded those missing audiometric thresholds (analytic sample, n=1,751). We defined audiometric hearing loss using the better-ear pure-tone average (mild, 26-40 dB hearing loss; moderate or greater, > 40 dB hearing loss). We

identified 23 clinically relevant candidate ICD-10 diagnostic codes for age-related sensorineural hearing loss for prediction models. We then used LASSO regression to select a subset of codes to build several prediction models to identify hearing loss accounting for age, self-reported sex, and self-reported Race. We compared model performance against reference-standard audiometric hearing loss by estimating the area-under-the-curve with cross-validation (CV-AUC), and estimated sensitivity, specificity, and predictive values. We also stratified models by self-reported Race and sex.

Results: Among eligible participants (mean age, 79.6 years; 60.4% female; 22.3% Black), the prevalence of reference-standard mild and moderate or greater hearing loss was 37.8% and 29.0%, respectively. Three candidate codes for hearing loss with high prevalence were retained based on LASSO regression (H90.3, H91.93, and H91.90). Several prediction models performed reasonably well in identifying hearing loss, with overall performance increasing with hearing loss severity (>25 dB hearing loss: CV-AUC: 73.5% [95% Confidence Interval [CI]: 70.8%, 75.8%], sensitivity: 70.5% [95% CI: 68.8%, 72.2%], specificity: 65.9% [95% CI: 63.5%, 68.0%]; >40 dB hearing loss: CV-AUC: 75.1% [95% CI: 72.0%, 77.2%], sensitivity: 72.6% [95% CI: 70.6%, 74.6%], specificity: 64.6% [95% CI: 56.2%, 73.0%]). In stratified analyses, models tended to perform better among White participants (CV-AUC: 73.5% [95% CI: 70.2%, 75.9%]) relative to Black participants (CV-AUC: 66.9% [95% CI: 58.6%, 73.9%]).

Conclusions: Medicare claims-based models for age-related hearing loss demonstrated strong face validity, albeit achieved acceptable levels of accuracy against reference-standard audiometric hearing loss. Validation in larger national datasets, and in demographic subgroups, is warranted to gain better insight into claims-based algorithm performance in identifying hearing loss.

Category: Hearing Loss / Rehabilitation

Poster #: 206

Hearing Aid Fitting Benefits in Children with Mild Hearing Loss

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Objectives: In Australia, 3-4 out of every 1,000 children under 9 years of age are diagnosed with mild hearing loss (HL), i.e., 20-40 dB HL in the better ear. Children with mild HL (CmHL) are likely to struggle when having conversations in noise despite having near-normal speech perception in quiet. Mixed evidence of hearing aid (HA) fitting benefits among CmHL has led to guidelines that emphasize personalized management, making it challenging for clinicians to suggest intervention options. The objective of this study is to examine HA fitting benefits in CmHL and identify the influencing factors. We hypothesized that difficulties with speech-in-noise perception in CmHL in the better ear are primarily dictated by suprathreshold processing abilities rather than reduced audibility. To test this hypothesis, we focused on auditory temporal and spectral processes, which are the two main predictors of speech

perception in noise among adults with hearing loss, while accounting for variance in working memory capacity.

Design: Behavioral measures of speech perception in noise and objective measures of spectral and temporal processing using functional near-infrared spectroscopy (fNIRS) are conducted in a group of CmHL 5-12 years of age and another group of age- and sex-matched neurotypical children with normal hearing (CNH). Speech perception in noise is assessed in three conditions, with speech (word stimuli) always being presented from a front loudspeaker. Noise (a two-talker babble) is presented from the same, left or right loudspeaker (-/+ 45 degree azimuth), with a copy of the noise being presented from the front loudspeaker with 3-ms lagging from the lead noise. Due to the precedence effect, this design results in the noise being perceived from the front, left, or right, respectively, hence being collocated with or spatially separated from the speech from the front. fNIRS responses are recorded in the bilateral temporal area, when children listen to broadband noise that was unprocessed (reference), 4-Hz amplitude-modulated (AM), and spectral-ripple noise modulated (SRN). The varying working memory capacity across children is assessed using NIH cognition toolkit.

Results: We have tested 9 CNH and 3 CmHL so far. The speech task so far revealed the expected benefit from spatial separation for both CNH and CmHL in the aided conditions, manifested as better performance when the noise was perceived from the left or right compared to when noise was from the front. No evidence of benefit from spatial separation was observed among CmHL when the better ear with mild HL was unaided. Results from fNIRS measurements indicate stronger responses in the AM and SRN conditions compared to the reference condition in all individuals. For CmHL, however, a broader brain region activated by AM and SRN could be observed when they were tested in the aided condition compared to the better-ear unaided condition, and this is consistent with the activation pattern in the CNH group.

Conclusions: With planned testing of 35 CNH and 35 CmHL, we will evaluate whether HA fitting in the ear with mild HL affects speech-in-noise perception and spatial release from masking. Further, we will evaluate how HA fitting influences sensitivity to spectral and temporal processing, and whether these processes are associated with speech perception in noise in children.

HEARING SCIENCE / PSYCHOACOUSTICS

Category: Hearing Science / Psychoacoustics

Poster #: 207

Effect of Interaural Level Differences on Lateralization and Fusion Perception

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Objectives: Binaural hearing is crucial to performance in tasks such as sound sourcelateralization. While binaural fusion and lateralization are two important binaural abilities, it isunclear whether lateralizing

sounds requires first fusing the sounds from the two ears into asingle percept (binaural fusion), or if fusion and lateralization interact at all. This study aims todetermine if listeners can lateralize both fused and unfused signals, and if lateralizationinfluences the ability to fuse.

Design: In this study, fifteen normal hearing listener's ability to lateralize and fuse sound was measured while manipulating interaural level differences, a key factor in lateralization. The stimuli were vocoded signals with envelopes derived from frequency-limited speech tokens with varying interaural correlations. Participants saw a graphic of a head with a blue oval in thecenter. They were instructed to indicate the perceived size, number, and lateralization of theperceived auditory image(s) using a dial.

Results: The results show that the ability to fuse sound rapidly decreased as the interauralcorrelation of the signal decreased. Additionally, as ILD magnitude increased, so did theperceived lateralization of the stimuli. Critically, this occurred even for stimuli that participantsindicated was completely unfused (i.e., they indicated that they heard separate images in theirleft and right ear) when there was no ILD. Adding the ILD not only resulted in a lateralizedpercept, but it also resulted in a more fused percept, especially for stimuli that had a completelyunfused ILD.

Conclusions: The results suggest that lateralization does not require first fusing a signal. However, it does suggest that fusion and lateralization interact, with lateralization potentiallyincreasing binaural fusion. However, future research will need to investigate if the increase inperceived fusion with ILDs reflects a true change in the dispersion of the perceived sound or ashift in attention towards the signal delivered to one ear.

Category: Hearing Science / Psychoacoustics

Poster #: 208

How Do Working Memory, Task Load, and Age Affect Distractibility?

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Objectives: Auditory distractions are experienced daily and are largely unavoidable. Despite their ever-presence, there is little agreement about sources of individual differences and mechanisms that drive distractor mediation; the latter is especially true with respect to the auditory domain. Listener differences are typically attributed to working memory capacity, where larger capacities are associated with reduced distraction; however, evidence from cross-modal designs has highlighted the importance of considering specific task demands as well. The present study aims to assess patterns of auditory distraction under various task loads and determine whether working memory limitations contribute to performance differences between younger and older adults.

Design: Initial data collection included young adults (18-30 years; n = 30, M-age =23.76) with normal hearing sensitivity, vision, cognition, and were native English speakers. Listeners were categorized into high- and low- working memory capacity groups based on their performance on a complex listening span task (high: n = 13, low: n = 17). Participants then completed two experimental tasks with varying load manipulations in quiet, steady state noise and multi-talker babble. Distraction was elicited via a response

competition paradigm. Experiment 1 was a directed dichotic listening task; the 'to-be-attended' ear switched between blocks of trials. Under low-load, listeners were to determine which of two targets (1kHz FM tone or white noise burst) was heard in the 'to-be-attended' ear while mediating distractors presented to the 'to-be-ignored ear'. Under high load, targets were further defined by their duration. For Experiment 2, targets and distractors were separated spatially; targets could appear in one of four 'frontal' locations relative to 0 degrees azimuth and distractors were always presented at +/- 90 degrees azimuth. Load was determined by the number of sounds included in the 'frontal' array (Low - 2; High - 4). Recruitment of older adults (55-80 years) with normal to mild hearing sensitivity (thresholds< 40 dB HL) is ongoing.

Results: Initial analyses evaluated the following: (1) efficiency of load manipulations, (2) patterns of distraction across conditions, and (3) working memory capacity group differences. Consistent with existing work, high load for both experiments yielded increased reaction times and poorer accuracy compared to low load. Patterns of distraction, however, differed between the two experiments. Distractibility was increased under high load within Experiment 1 but did not differ between load conditions within Experiment 2. Per working memory capacity, high-capacity listeners consistently performed faster and more accurately than low-capacity listeners but never exhibited superior distractor mediation. Interestingly, high-capacity listeners showed greater distractibility within Experiment 2 than their low-capacity counterparts. Further analyses including older adults and additional group differences are being conducted.

Conclusions: Thus far, results indicate that during directed listening (Experiment 1) young listeners' distractibility is driven by task load and not influenced by working memory capacity. In contrast, during auditory search-like listening (Experiment 2) their performance is driven by working memory capacity more so than task load. Inclusion of older adults will provide greater insights into the role of working memory limitations across task loads and continue to decode reports of difficulty in complex listening environments, or effortful listening.

Category: Hearing Science / Psychoacoustics

Poster #: 209

The Effect of Reverberation on Spatial Release from Masking

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Objectives: This study investigates the influence of reverberation on speech identification in multi-talker scenes, focusing on the binaural cues that are crucial for distinguishing speech from background noise.

Our main objective is to determine whether spatial release from masking (SRM) is reduced in reverberation compared to anechoic conditions. Additionally, we aim to determine if the sensitivity to interaural time differences (ITD) and interaural level differences (ILD) can predict the effect of reverberation on SRM.

Design: Young adults with normal hearing (ages 19-55), completed a speech-on-speech recognition test using Bamford-Kowal-Bench (BKB) sentences presented with continuous background masking speech. Testing took place in an anechoic chamber with an array of 64 loudspeakers. In anechoic conditions, target speech and two masker streams were presented from a single frontal loudspeaker (co-located) or from three loudspeakers separated by 45 degrees (separated). In reverberant conditions, reflections were calculated via modified source image model and presented from the full loudspeaker array. ITD and ILD discrimination thresholds were separately measured over headphones using two-alternative forced choice task.

Results: Speech reception threshold (SRT) was defined as the target to masker ratio required for 75% correct word-level performance in each condition. SRM was calculated as the difference in SRT between co-located and separated conditions. Linear mixed models were used to determine associations between SRT, SRM, interaural thresholds, and listening conditions. Co-located SRT and differences observed in reverberant conditions were moderately related to listeners' binaural sensitivity (ITD/ILD thresholds).

Conclusions: This study elucidates speech perception capabilities of individuals with normal hearing in challenging auditory scenarios. Additionally, the link between room acoustics, speech audibility, and communication outcomes for normal hearing individuals is explored.

Category: Hearing Science / Psychoacoustics

Poster #: 210

Modulation Spectral Feature Analysis and Valence of Non-Speech Sounds

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Objectives: One perceptual consequence of hearing loss is a reduced range of emotional responses to sounds; adults with hearing loss exhibit ratings of valence that are less extreme (less pleasant and less unpleasant) than do their peers with normal hearing. This has important implications for overall quality of life because a full range of emotional experiences is necessary for overall well-being. Although the acoustic cues for arousal are clear (i.e., louder sounds are more exciting), the identification of acoustic cues that contribute to ratings of valence has been somewhat elusive. The purpose of this project was to evaluate the potential for spectrotemporal amplitude modulation to cue for ratings of valence in response to non-speech sounds.

Design: Adults with normal hearing and hearing loss rated emotional responses to non-speech sounds (e.g., animal noises, social noises, music). The sounds were then subjected to modulation spectral feature analysis by dividing each sound into 17 frequency bands and analyzing the modulation energy at 7 different modulation rates (2 - 128 Hz). Then, k-means cluster analysis was conducted to evaluate the

degree to which particular amplitude modulation rates in particular auditory frequency bands could be grouped in informative ways. Ratings of valence were then subjected to linear regression with stimulus category (pleasant, neutral, unpleasant), group (normal hearing, hearing loss) and standardized modulation energy in each cluster as within-participant factors; participant identifier was used as a random intercept.

Results: Cluster analysis revealed that the modulation data were well-described with two clusters, one cluster that includes high modulation energy in the 1000-1270 Hz region, especially for modulation rates of 2, 4, and 8 Hz (cluster 1) and one cluster that includes low-level modulation energy across most frequencies and modulation rates (cluster 2). Regression analysis revealed ratings of valence were less extreme for sounds with more modulation energy in cluster 2. In addition, ratings of valence were higher (more pleasant) for pleasant and unpleasant sounds when modulation energy in cluster 1 was higher. These findings were generally similar across both groups of listeners.

Conclusions: The results of this study highlight the importance of slow amplitude modulation in the 1000-1270 Hz region for cuing valence in non-speech sounds for all listeners; sounds with higher modulation energy were rated as more pleasant than were sounds with less modulation energy. However, this effect was similar for listeners with and without hearing loss. Therefore, although slow amplitude modulations in this frequency range are important for pleasantness, this finding does not offer additional insight into the mechanisms for the reduced range of emotional responses to sounds for adults with hearing loss. Additional work is necessary to evaluate the effect of hearing aids, particularly with amplitude compression, on these modulation cues and emotion perception of non-speech sounds.

Category: Hearing Science / Psychoacoustics

Poster #: 211

Exploring Level Effects in Auditory Enhancement: Implications for Hearing Loss

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Objectives: Auditory enhancement refers to the improved audibility of a target sound in the presence of a spectrally flanking masker, when the masker is first presented alone as a precursor. This large (20-dB) effect found in young normal-hearing listeners is thought to reflect the auditory system's capacity to adapt to changing acoustic environments and to facilitate the detection of new sounds in an ongoing background. Hearing-impaired listeners have been found to show severely reduced enhancement under these conditions. However, it remains unclear whether the lack of an effect in hearing-impaired listeners is due to the effects of hearing loss, or due to the high sound levels needed to ensure audibility (or both). The present study systematically examines the effects of masker presentation level on auditory enhancement in young normal-hearing listeners and explores the potential interactions with spectral resolution. The aim is to better understand the properties and mechanisms of auditory enhancement, with the goal of restoring this potentially important effect in people with hearing loss.

Design: Young normal-hearing participants (N = 30) were asked to judge whether the pitch of a 100-ms probe tone matched that of a preceding 100-ms target tone, embedded in a complex of simultaneous,

spectrally flanking masker tones. The target-masker complex was symmetrically centered on a logarithmic scale around 1414 Hz, and was presented with (ENH condition) or without (MSK condition) a 300-ms precursor containing just the masking tones. All components in the target-masker complex and precursor were spaced apart by either 0.3 or 0.6 octaves. The masker components were presented at a fixed sound level of 45, 57.5, or 70 dB SPL per component. Thresholds for the target tone, measured with an adaptive tracking procedure, were used to quantify enhancement as the difference in threshold between the MSK and ENH conditions.

Results: With a 0.3-octave spacing between spectral components, results replicated previous findings of a large enhancement effect (15-20 dB) at the lower (45-dB) level. The amount of enhancement progressively decreased with increasing masker level. At the 0.6-octave component spacing, most enhancement was observed at the intermediate (57.5-dB) masker level, with the least enhancement still found at the highest (70-dB) masker level. The results suggest an interaction between masker level and component spacing that is qualitatively in line with the expected effects of level on auditory frequency selectivity.

Conclusions: Auditory enhancement was confirmed to have a large perceptual effect in young normal-hearing listeners. At the standard spectral spacing of 0.3 octaves, enhancement was systematically reduced with increasing masker level. However, with wider spectral spacing, maximum enhancement was observed at the medium masker level. The results suggest that enhancement may depend on the level of the target, rather than that of the masker, in ways that are potentially related to basilar membrane compression, which is reduced at high levels and with hearing loss. It may be possible to restore some degree of enhancement via channel-specific gain control in hearing aids. [Work supported by NIH grant R01 DC012262.]

Category: Hearing Science / Psychoacoustics

Poster #: 212

Assessing Auditory-Spatial Stroop Task Performance Under Working Memory Loads

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Objectives: The purpose of this experiment was to evaluate the impact of different types of working memory (WM) load on an auditory-spatial Stroop task. Stroop tasks have been widely used in cognitive psychology experiments to evaluate selective attention and inhibitory control; participants are faster and more accurate at identifying targets that are congruent with distracting stimuli compared to targets that are incongruent. A relatively recent set of studies introduced Special Load Theory- the concept that information held in WM can be either inhibitory or facilitative for target selection based on the WM load's relationship to the task goals. The objective of this study was to apply the concepts of Special Load Theory to an auditory-spatial Stroop task to investigate how different WM loads affected target selection in a well-known experimental task paradigm. It was hypothesized that target selection performance would decrease when the WM load shared features of the target selection goals and improve when the WM load shared features of the distractors.

Design: Data were collected for 43 adult participants (M = 23.1 years, SD = 4.2 years) with normal hearing, vision, and cognition. Target stimuli were the spoken words right, left, and front, with each word recorded from right, left, and front spatial locations using a KEMAR manikin. Stimuli for the WM loads were bursts of pink noise recorded from the same right, left, and front spatial locations, and the spoken words hand, pill, and shoe recorded with no spatial cues. The experiment consisted of three conditions conducted over headphones: the Spatial Load condition presented a combination of three spatialized noise bursts followed by a spatialized target word (right, left, front), the Verbal Load condition presented a combination of non-spatialized words hand, pill, and shoe followed by a spatialized target word, and the No Load condition presented only a spatialized target word. The objective of the task was for the participants to remember the order of the three items from the WM loads, indicate the spatial location of the target word, then recall the order of the three WM load items. In the No Load condition, participants were only required to indicate the spatial location of the target word.

Results: Results showed that target selection performance was significantly better in the Verbal Load condition compared to the Spatial Load and No Load conditions. There was not a significant difference in performance between Spatial Load and No Load conditions.

Conclusions: The results of this study offer partial support for Special Load Theory and extend it into the auditory-spatial domain. These findings show that when a WM load shares features of the task target goal (spatial location detection), cognitive resources become encumbered by the WM load and target selection performance suffers. However, when the WM load shares features with the distracting component (verbal/semantic meaning), cognitive resources are occupied by the WM load which prevents processing of distracting information and thus improves task performance. This study offers insight into how listeners utilize selective attention to navigate complex listening environments.

Category: Hearing Science / Psychoacoustics

Poster #: 213

Physical Exertion as a Novel Index of Listening Effort

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Objectives: Attending to and understanding speech in noisy environments can be challenging. Measuring the corresponding increases in listening effort is therefore important for investigating the cognitive mechanisms involved in speech perception, and for assessing the effectiveness of interventions that address hearing impairments. While there are currently three well-established categories of listening-effort measures-self-report, behavioural, and physiological- there are limitations to each. Here we examined a novel index of listening effort based on prior evidence in the visual domain that individuals readily exert physical effort to secure easier perceptual conditions. An important, unique aspect of this approach is that physical exertion is measured before each trial, which-in line with the Framework for Understanding Effortful Listening (FUEL)-provides a record of participants' motivation to expend effort during the subsequent listening period. We hypothesized that participants would exert more physical

effort to achieve easier listening conditions for trials containing low-predictability sentences and those with higher initial levels of background noise.

Design: Participants (undergraduates: total N = 189) exerted physical effort through repeated button-pressing before each trial to reduce levels of background noise in a subsequent speech-identification task. The use of a progressive-ratio schedule meant that participants had to make an increasing number of key presses prior to each successive trial within a block to obtain easier listening. Different blocks of trials contained either predictable or unpredictable sentences. Experiment 1 provided unlimited time for key-pressing and varied the initial level of background noise (high, medium). Experiment 2 followed the same design but employed roughly half as many total trials. This experiment also collected subjective ratings of effort at the end of each trial, and examined whether individual differences in boredom, distractibility, and absorption affect the motivation to keypress for easier listening conditions.

Results: In Experiment 1, key-pressing was greatest for unpredictable sentences and those with higher initial levels of background noise, and it consistently increased with the progressive-ratio requirement for ever-greater numbers of key-presses to obtain easy listening conditions. These findings were also evident in Experiment 2, despite using every other value in the progressive-ratio schedule, and thus roughly half as many total trials. Our novel index of listening effort also obtained ηp2 values as large as 0.60. Finally, the incorporation of individual measures in Experiment 2 revealed that our index of listening effort is not significantly affected by differences in age, self-reported hearing ability, or trait boredom, distractibility, and absorption.

Conclusions: These findings provide converging evidence that understanding speech in noise is effortful, and that this can motivate participants to invest physical effort in order to make listening easier. Measures of physical exertion may therefore provide a path towards a useful objective index of listening effort. While our novel index of listening effort seems promising for inclusion in an audiologic outcome battery (i.e., efficient, easily administered, and requires no specialized equipment), future work is needed to investigate its clinical potential in determining the effectiveness of hearing-rehabilitation interventions. Additional work should also directly compare the efficacy of this new index of listening effort with other pre-existing measures.

Category: Hearing Science / Psychoacoustics

Poster #: 214

Exploring Behavioral Masking and OAE Suppression Using Frequency Sweeps

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Objectives: Previous recordings of mouse basilar-membrane (BM) motion in response to exponential frequency chirps have shown that upward sweeps (i.e., from low to high frequency) are more effective suppressors of tonal probe signals than downward sweeps (high to low). That study found that the differential suppressive effects of sweep direction depend strongly on sweep rate, being stronger for faster sweeps. These results in mice are reminiscent of findings from human perceptual studies using so-called "Schroeder-phase complexes," which are stimuli that contain multiple harmonic frequency

components of equal amplitude but variable starting phase, summing to produce a series of periodic linear frequency sweeps. Behavioral studies find that negative Schroeder-phase maskers (e.g., upward sweeps) are more effective maskers of tonal signals than positive Schroeder-phase maskers (e.g., downward sweeps). In our recent work, we measured behavioral masking and otoacoustic emission (OAE) suppression as a function of sweep rate and direction in normal hearing humans. Consistent with the sweep direction effects in the Schroeder masking literature, the upward sweeps were more effective maskers/suppressors than downward sweeps. Unexpectedly, we found that the largest up-down differences in both behavioral masking and OAE suppression occurred at sweep rates of approximately ~50 oct/s. This rate of peak effectiveness matches otoacoustic estimates of the group velocity of the traveling wave. These results suggest that both behavioral masking and OAE suppression share common mechanisms, presumably closely related to mechanical suppression in the cochlea.

Design: The current study builds on our recent efforts investigating the effects of sweep rate and direction in normal hearing humans, both behaviorally and physiologically. Frequency sweeps are used in both behavioral masking and stimulus-frequency otoacoustic emissions (SFOAEs), either as maskers or suppressors, respectively. We explore the test-retest reliability of our modified SFOAE suppression paradigm to determine the consistency of our estimates of cochlear suppression. In addition, we measure the effects of sweep rate and direction at a higher signal/probe frequency (~4 kHz) to determine whether the dependence on sweep rate and direction varies with location in the cochlea. We hypothesize that the use of these stimuli will provide new opportunities to relate masking and suppression to cochlear processing.

Results: Differences in psychoacoustic masking and OAE suppression for various sweep combinations will be explored and compared. To the extent that the two phenomena share common generation mechanisms, we expect behavioral masking and OAE suppression to depend similarly on sweep characteristics.

Conclusions: The long-term goal of our study is to better understand dynamic aspects of nonlinear signal processing in the cochlea. Here, we expand on previous work in mice and in humans to explore the effects of frequency sweep rate and direction on signal suppression and masking in normal hearing human listeners.

Category: Hearing Science / Psychoacoustics

Poster #: 215

Comparing Measurement Methods of Minimum Angular Separation for Spatial Unmasking

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Objectives: In a novel measure of spatial release from masking, Peng and Litovsky (2021) assessed the minimum angular separation (MAS) required between a target and two-talker masker to achieve a fixed 20% improvement in intelligibility from the spatially collocated condition. The current study has two key aims. First, to compare various MAS measurement methods to provide a robust and clinically feasible

assessment procedure. Second, to investigate the relationship between target-masker angular separation and signal-to-noise ratio in spatial release from masking.

Design: Normal hearing young adults were tested with headphones in a simulated virtual free-field using a set of head-related transfer functions measured anechoically. Target speech was AuSTIN sentences with three keywords presented at a fixed location on the side, with a two-talker same-sex masker of continuous discourses. To measure MAS, we first obtained the collocated signal-to-noise ratio (SNR) thresholds using two interleaved staircase adaptive tracks (i.e., one-down-one-up). We reconstructed the psychometric functions to estimate SNR30 and SNR50 at 30% and 50% keyword accuracy, respectively. Next, using the collocated SNR50, MAS was measured by displacing the masker location toward center to arrive at 70.7% keyword accuracy. MAS70 thresholds were measured and compared using three methods: (1) method of constant stimuli, with ten sentences presented in fixed levels of angular separation; (2) staircase adaptive tracking, using a two-down-one-up adaptive procedure; and (3) progressive tracking, with two sentences presented at each of nine target-masker separations in ascending and descending order. The test order for the three methods of obtaining MAS followed a balanced Latin Square. We also measured MAS70 under SNR30 using method of constant stimuli. The relationship between angular separation and SNR was assessed by correlating MAS70 measured under SNR30 and SNR50.

Results: MAS obtained using the different measurement methods were compared. From preliminary data, we observed a trend of best (lowest) MAS thresholds from method of constant stimuli, with similar MAS estimated from progressive tracking through both directions. The adaptive staircase procedure produced the worst (highest) MAS thresholds. Repeated adaptive staircase measurements did not improve MAS estimate. Test order did not impact the MAS threshold. Goodness-of-fit of the reconstructed MAS psychometric function was examined using R-squared. MAS70 was highly correlated with SNR.

Conclusions: We compared three methods to measure MAS thresholds, a novel measure of spatial release from masking. In general, MAS thresholds are sensitive to SNR change. It is important to obtain SNR50 in the first step for individuals to achieve good MAS estimation. The MAS threshold may be robustly estimated using fewer trials for improved clinical feasibility.

Category: Hearing Science / Psychoacoustics

Poster #: 216

Relating Self-Reported Hearing Experience to Reverberant Spatial Speech Unmasking

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Objectives: Some listeners report difficulties hearing speech in the presence of competing talkers. However, many standardized measures of speech in noise are not strongly correlated with listener's reports. This might be because current clinical tests are not representative of the variety of listening situations with which listeners report difficulty. To investigate this possibility, we tested listeners' masked speech understanding in more realistic environments than typically tested using reverberant and spatially separated masker conditions and collected information about their everyday hearing experience.

Design: Participants were adult listeners (age: 19-55) with normal hearing. Listeners' hearing status was characterized by multiple measures including pure tone audiometry, binaural sensitivity (interaural time and level difference (ITD/ILD) thresholds), and three questionnaires: The Speech, Spatial and Qualities of Hearing scale short version (SSQ-12), the Hearing Handicap Inventory for Adults (HHIA), and the Concussion Symptom Subtype Inventory (CSSI). These questionnaires are intended to capture the listener's experience regarding their hearing abilities and challenges across everyday tasks. Speech intelligibility was measured using Bamford Kowal and Bench (BKB) sentence targets recorded by a female talker. Maskers were spoken narratives recorded by two additional female talkers. Stimuli were presented over loudspeakers in an anechoic chamber. Participants verbally reported each target sentence, and each word was recorded as correct or incorrect. Target to masker ratio (TMR) varied adaptively; psychometric functions fit to the data were used to estimate speech reception threshold (SRT) in each of four conditions. Spatial release from masking was computed as the SRT difference between conditions with target-colocated vs. spatially separated maskers, presented anechoically or in simulated reverberation. Multivariate analysis was used to correlate SRT, SRM, ITD/ILD thresholds, and item scores on the SSQ-12, HHIA and CSSI questionnaires.

Results: Individual participants varied in overall performance (SRT), SRM, and spatial hearing abilities as assessed by the SSQ-12 and ITD/ILD thresholds. Some associations among these measures were noted. Because initial testing focused on participants with negative history of hearing impairment and concussion, lack of variance limited associations with HHIA and CSSI scores.

Conclusions: By reproducing realistic everyday listening challenges, measures of speech-on-speech masking in reverberant and spatially separated conditions have the potential to better capture significant variation in listeners' hearing complaints. Additional testing will be required to demonstrate the clinical utility of this approach.

HEARING TECHNOLOGY / AMPLIFICATION

Category: Hearing Technology / Amplification

Poster #: 217

Real-world Hearing Aid Outcome Assessment in India: An EMA Study

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Objectives: The study aims to compare real-world outcomes between premium and basic hearing aid (HA) technology in India as a part of larger research into HA algorithms in developing and developed countries. Using smartphone-based ecological momentary assessment (EMA) self-reports and HA environmental classification, the research seeks to evaluate the performance of HA algorithms. The hypothesis posits that premium technology in India will demonstrate performance comparable to that of basic technology.

Design: In a single-blinded, counterbalanced, prospective study, ten English-speaking experienced HA users aged 40-80 years were selected to participate in India. Basic and premium technology Unitron Flex RIC hearing aids were fitted to the participants, serving as an exemplar of currently available technology across manufacturers. The HAs were programmed according to the manufacturer's proprietary fitting formula with recommended default parameters. The 'Log-It-All' data logging feature was enabled to monitor users' environment classification. Each participant was provided with a smartphone with the AudioSense EMA app. Self-report surveys were collected four times/day over a week for each HA technology. A one-week gap period was included for technology wear-off effects. The survey had ten questions to assess HA outcome domains, including benefit, satisfaction, and listening effort. Additionally, the survey collected information about users' listening environments. Retrospective self-reports were obtained at the end of each week's data collection.

Results: A total of 403 surveys were collected (79% compliance rate). The raw data were transferred from mobile devices to a computer, where researchers thoroughly analyzed data quality. Nine participants were included in the data analysis using a linear mixed effects model. One participant was excluded from the analysis as they did not wear their hearing aids. A random intercept model was applied, examining the fixed effects of technology on benefit, satisfaction, and listening effort, with random effects accounting for individual participants across various time points and days. Results demonstrated significant effect of technology on benefit, specifically in speech understanding ($F(1, 321)= 25.14$, $p<.001$) and usage ($F(1, 392)= 7.73$, $p=.006$), as well as on listening effort, including effortful listening ($F(1, 332)= 6.02$, $p=.015$), and ease of listening ($F(1, 333)= 9.48$, $p=.002$). However, benefit scales (HA help, performance) and satisfaction scales did not reveal a significant effect of HA technology. Basic HA showed significantly better outcomes compared to premium HA.

Conclusions: Based on the findings of the analysis, although basic HA technology showed significantly better scores in speech understanding and listening effort, the mean differences were marginal (mean difference= 0.1-0.3), and clinically insignificant. Overall, HA satisfaction and performance were comparable for both technology levels in the Indian location offering clinicians valuable insights for managing expectations. The identified, individual variability can potentially provide useful information for individualized hearing aid fitting and counseling. These findings aid users in making cost-effective HA choices based on their listening needs. Future analysis with respect to the specific listening environment would guide researchers about the real-world applicability of hearing aid technology levels in different parts of the world due to the variability in the acoustic environment.

Category: Hearing Technology / Amplification

Poster #: 218

Fit it Right, Hear It Right With Check My Fit

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Objectives: Incorrect self-insertion of hearing devices can pose challenges for users of hearing aids. In the absence of proper guidance, confirming the correct placement of devices becomes a complex task. Inaccurate insertion may give rise to critical issues, such as a decrease in insertion gain and an elevated risk of feedback, both of which can negatively impact the overall performance of HAs. Furthermore, improper insertion has the potential to diminish the user's perceived benefits, heighten feelings of annoyance, and disrupt the adaptation process.To address this concern, GN has developed a solution named Check My Fit, designed to facilitate the accurate insertion of HAs. Leveraging machine learning, Check My Fit captures a photo when the ear is correctly positioned, highlighting the location of the receiver wire. The user interface enables a side-by-side comparison between the current photo and a reference image taken during the initial HA fitting. The objective of this research is to determine whether the application of Check My Fit influences accuracy of insertion gain when end users fit their own hearing instruments. It is hypothesized that the application of Check My Fit will significantly influence the accuracy of insertion gain when end users independently fit their own hearing instruments. It is expected that users employing Check My Fit will exhibit heightened precision in insertion gain compared to individuals who do not utilize the application.

Design: Twenty participants will be randomly assigned to one of two groups: Group A, which will use the intervention from the beginning, and Group B, which will be introduced to the intervention midway through the trial. The intervention involves the use of a smartphone application designed to assist users in correctly placing hearing instruments on the ear. Healthcare providers will provide guidance to both groups on the correct placement of the hearing instruments. Healthcare providers will measure insertion gain in both groups to establish a baseline for correct placement, serving as the initial reference point.Group A will begin using the app immediately, receiving guidance from HCPs on proper hearing instrument placement. Group B will be introduced to the intervention midway through the trial, also receiving guidance from HCPs. Participants in both groups will be responsible for placing the hearing aids on their own, following guidance provided by the HCPs and using the app through the trial.HCPs will conduct insertion gain measures post-intervention to assess the impact of correct placement using the app in both groups. The study will examine whether participants can effectively learn the correct way to place hearing aids on the ear by utilizing the app. The results will be compared between the two groups at the end of the trial.

Results: Preliminary data suggests a correlation between its usage and improved insertion quality, hinting at potential advantages for new users.

Conclusions: Check My Fit is a smartphone-based automated solution that enables users to quickly take a photo of their hearing aid placement and compare it against an optimal reference insertion. The clinical implications of Check My Fit are significant in the field of audiology and hearing healthcare and will enhance end-user self-management, improved end-user compliance, reduced dependency on HCPs and follow up appointments, quality assurance for hearing aids and patient education and empowerment.

Category: Hearing Technology / Amplification

Poster #: 219

Individualizing Help-in-Noise Hearing-Aid Settings with the Audible Contrast Threshold (ACT)

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Objectives: The primary diagnostic tool employed in clinical audiology for hearing loss assessment is the pure-tone audiogram, which forms the foundation for setting hearing-aid amplification. However, the

audiogram does not fully capture the residual hearing challenges that persist when audibility is restored, particularly speech understanding in adverse conditions. Such above-threshold difficulties can be quantified with speech-in-noise tests. Nonetheless, a number of barriers limit the value of these tests for clinical practice, such as the need for additional equipment, long testing time, language dependence, poor ecological validity, lack of audibility compensation, and a large diversity of speech materials to choose from. Importantly, there is currently no standard evidence-based way to adjust hearing-aid settings based on speech-in-noise test results. A clinically viable test that can predict speech-in-noise performance in ecologically valid settings would thus be a valuable addition to the evaluation of a patient's hearing abilities. This study investigated the extent to which the Audible Contrast Threshold (ACTTM) test can be used to predict speech-in-noise performance once hearing-aid amplification has been provided, in two different clinical populations with different native languages. ACT is a novel, fast, and straightforward clinical test that measures spectro-temporal modulation detection abilities of the patient while taking their hearing thresholds into account.

Design: Participants with a wide range of hearing losses were recruited in Germany (N = 81) and Japan (N = 19) and were fit with Oticon MoreTM 1 hearing aids following standard clinical practice at each site. The audiogram, ACT value, and aided speech reception threshold in noise (SRTn) of the patients were obtained. The SRTns were determined in an ecologically-valid version of the Hearing In Noise Test with spatially distributed speech interferers, while listeners were using the hearing aids in four different MoreSound IntelligenceTM (MSI) settings: Off (amplification only), Low, Moderate, and High.

Results: At the group level, SRTns decreased, i.e., speech-in-noise performance increased, as the MSI help-in-noise setting increased. SRTns collected with MSI Off showed a significant correlation with ACT in both language groups. In a three-predictor linear regression model, ACT, the 4-frequency pure-tone average (PTA4), and to a lesser extent age, were found to contribute significantly to the prediction of aided speech understanding in noise with amplification only. ACT outperformed the audiogram in predicting SRTs, and thus added to the predictive power of the audiogram. Taken together, ACT, PTA4, and age were also linked to the individual SRTn improvements observed with the different MSI help-in-noise settings, indicating that they could be used to determine meaningful help-in-noise settings for different patient groups.

Conclusions: These results indicate that the ACT test provides a measure that greatly increases the prediction of patients' speech-in-noise abilities compared to the audiogram alone, and that ACT values can be used to objectively prescribe hearing-aid help-in-noise settings. In the present study, the ACT test was also found to take less than 2 minutes on average and to have excellent test-retest reliability, enabling audiologists to give their patients a quick and evidence-based first fit of help-in-noise features.

Category: Hearing Technology / Amplification

Poster #: 220

Pilot Clinical Trial: Self-Guided CBT-Based Smartphone Program for Tinnitus Management

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Objectives: Cognitive behavioral therapy (CBT) is well-researched with substantial evidence for alleviating distress and enhancing well-being of individuals with bothersome tinnitus. Despite the evidence, CBT remains underutilized, emphasizing the need for a scalable CBT approach with evidence-supported efficacy and user-friendly accessibility. As a first step, we have performed a pilot study with a novel, self-guided, smartphone-delivered, CBT-based program. The study explored the acceptability, safety, and clinical outcomes of the program in adults with bothersome tinnitus. The goal of this pilot study was to assess the feasibility of a full-scale randomized controlled trial (RCT).

Design: A single-arm, open-label study enrolled 97 adult participants with bothersome tinnitus. Enrollment criteria included a Tinnitus Functional Index (TFI) score of ≥ 25 and tinnitus-related symptoms for ≥ 3 months. Participants were given access to Mahana Tinnitus, a self-guided smartphone-delivered program that guides users through 5 sessions with a total of 27 interactive lessons. The program teaches techniques to reduce the impact of tinnitus sounds, guides the development of personal tinnitus management strategies, and provides tools for identifying and changing unhelpful tinnitus-related habits. Participants had 6 weeks to complete the self-paced program. All participants who were enrolled and granted access to Mahana Tinnitus were included in the intent-to-treat analysis population. Single-factor, mixed-effects linear regression modeling with Wald X-squared tests evaluated changes from baseline for standardized questionnaires. Data are reported as mean ± 95% confidence interval.

Results: Participants had a mean age of 57 years old, ranging from 21 to 81 years. Half of participants (n = 50) were program adherent (completed 3 out of 5 sessions), and 37% (n = 36) were program completers. At baseline, most participants had moderate tinnitus severity. Significant reductions in both the TFI and Tinnitus Primary Function Questionnaire (TPFQ) scores at 6 weeks indicated a reduction in tinnitus severity (TFI: -20.50 ± 1.86, [X-squared (3, N = 97) = 131.89, p< 0.001]; TPFQ: -15.99 ± 2.55, [X-squared (1, N = 97) = 39.41, p< 0.001]). The TFI responder rate, defined as meeting a 13-point threshold for a clinically meaningful reduction in the TFI, was an estimated 61.3 ± 15.7% at 6 weeks. Participants found Mahana Tinnitus acceptable with a moderate to high mean mHealth App Usability Questionnaire score of 103.07 ± 17.55. No serious or intervention-related adverse events were reported.

Conclusions: The findings suggest positive improvements in tinnitus symptom severity, along with safety and ease of use for Mahana Tinnitus. The observed reduction in tinnitus severity aligns with established literature on CBT's effectiveness in managing tinnitus-related distress. The innovative smartphone delivery of a CBT-based program addresses accessibility barriers associated with clinician-led CBT. As such, Mahana Tinnitus holds substantial potential to impact clinical practice by providing a scalable, accessible, and effective intervention for tinnitus management. However, this study's single-arm design presents limitations; a definitive assessment of treatment effects necessitates further exploration through an RCT design. The findings support this next step, and underscore Mahana Tinnitus' considerable promise for individuals struggling with bothersome tinnitus.

Category: Hearing Technology / Amplification

Poster #: 221

Consumer Attention and Comprehension of the Over-the-Counter Hearing Aid Product-Information-Label

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Objectives: The Drug Facts Label (DFL) is the consumer-focused tool required by the Food and Drug Administration (FDA) to transmit essential health information about candidacy and use parameters to potential users of OTC medications. All DFL undergo a label comprehension study to evaluate comprehension by consumers with different levels of health literacy. However, not all OTC products are required to sport a DFL. The FDA requires other OTC products to have a product information label (PIL), but is not required to undergo comprehensibility as a DFL would. OTC hearing aids (HA) have a PIL that contains specific healthcare information, but it was not required to undergo a label comprehension study. Therefore, it is unknown if the OTC-HA PIL adequately transmits necessary health information to the average consumer. Unfortunately, the generalizability of label comprehension studies is limited, as these laboratory studies are designed to force the participant to fully examine the PIL. However, in the real-world consumers can take as little as 15 seconds to make a product selection. It is unclear what packaging elements draw consumers attention within that limited time. Eye-tracking experiments have been used to probe these questions, and show that consumers spend less time viewing warning information on the PIL compared to other aspects of the package (e.g., brand names, images). Unfortunately, these findings are exacerbated by lower levels of health literacy. Whether these trends hold for the OTC-HA PIL remains completely unexplored. Given the lack of systematic evaluation of the OTC-HA PIL, it is unknown if consumers are viewing the PIL in its entirety and if they are able to comprehend its' contents. The goal of the present study was to use eye-tracking to determine what consumers attend to when looking at an OTC-HA package (which includes the PIL), and conduct an assessment of comprehension of the PIL's content. We predict that individuals with lower health literacy will spend less time attending to the PIL and will have lower rates of comprehension compared to those with higher levels of health literacy.

Design: Twenty participants (10 females) were recruited using convenience sampling methods. All participants were above the age of 18, identified as Asian, reported English as a second language, had 20/20 (or corrected) vision, and were non-HA users. Health literacy was assessed using the Short Test of Functional Health Literacy in Adults. Using eye-tracking, participant attention was recorded when shown an OTC-HA package (which included the PIL) for 30 seconds. Participants were then administered a label comprehension study about the OTC-HA PIL using the FDA guidance for label comprehension studies.

Results: Results showed that participants with lower levels of health literacy spent less time attending to the OTC-HA PIL compared to other package elements (i.e., brand names, images). Only 4-items (19 total) of health information had a comprehension rate of 90% or higher. Comprehension rates were poorer for those with lower levels of health literacy for all health information items.

Conclusions: Participants with lower levels of health literacy spend minimal time attending to the OTC-HA PIL. Consumer comprehension of OTC-HA PIL health information is limited, and is greatly influenced by health literacy.

Category: Hearing Technology / Amplification

Poster #: 222 **Mentored Student Research Poster Award**

Communication Outcomes with OTC Hearing Aids

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Objectives: Over-the-counter hearing aids (OTC HAs) are a regulated class of medical devices designed to treat mild-to-moderate hearing loss (HL) in adults. However, research is lacking regarding the effectiveness of these devices to address the needs of adults seeking HL treatment. Adults with HL and their communication partners frequently report communication breakdowns, which disrupt the natural flow of conversation leading to misheard and inefficient communication. Additionally, adults with HL report that listening during communication is effortful. In this project, we investigated whether OTC HAs can improve communication. We predicted: (1) improved conversation accuracy and efficiency, measured through an analysis of conversation behavior during a structured communication task; and (2) reduced subjective listening effort, demonstrated by lower self-rating scores indicating decreased perception of effort during listening with OTC HAs.

Design: Thirty adults with bilateral mild-to-moderate sensorineural HL, each accompanied by a communication partner, enrolled in this study. Participants with HL were divided into two groups, Mild or Moderate, based on their audiogram. The OTC HA program selected for each participant was based on real ear measures to NAL-NL2 targets. Conversation analysis employed a 'spot the difference' task, wherein dyads used verbal-only cues to identify 12 differences between similar pictures. The participant and communication partner were each assigned a role as either the director or receiver for each trial. Accuracy was evaluated as the number of correctly identified picture differences, and efficiency was measured as the time taken to identify differences. Subjective listening effort was assessed following sentences-in-noise testing. Participants repeated back low- and high-context sentences in noise (5- and 10-dB SNR), and later were prompted to recall the sentences heard. A 10-point Likert scale was used to evaluate how effortful participants felt it was to listen to the sentences, ranging from not effortful to very effortful. Within-participant comparisons were conducted across three listening conditions: unaided; aided with participant's primary program; and aided with the noise reduction program.

Results: Conversation Analysis: Both Mild and Moderate groups performed near-ceiling for accuracy regardless of listening condition (unaided and aided). Descriptive statistics showed a slight improvement in overall group means for efficiency as observed in the aided condition compared to unaided, however this finding was not significant. Subjective Listening Effort: Both groups performed near-ceiling for recognition to high-context sentences, with and without OTC HAs. For low-context sentences, there was a minor decline in mean performance for both groups in the aided conditions compared to unaided; however, this observation was not statistically significant. No differences were found for recall between unaided and aided conditions. While subjective effort ratings varied among participants, the mean ratings for subjective listening effort reflected a high level of effort (very effortful) for both groups, with no effect of the listening condition (unaided and aided).

Conclusions: Although near-ceiling performance on conversation accuracy and speech recognition was observed with and without the use of OTC HAs, conversation efficiency and subjective listening effort ratings did not significantly improve with the use of these aids. Therefore, OTC HAs did not broadly improve communication outcomes across adults with mild-to-moderate HL in our study.

Category: Hearing Technology / Amplification

Poster #: 223

Current Nationwide Implementation of Best Practices for Pediatric Amplification

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Objectives: This study examined the implementation of best practices in pediatric hearing aid dispensing in the United States, focusing on early intervention for children with hearing loss. The analysis used data from the Early Hearing Detection and Intervention: Pediatric Audiology Links to Services (EHDI-PALS) survey, collected from 1,115 facilities. There were two key objectives: to determine the percentage of facilities providing hearing aids to children under 6 months and to explore national trends in pediatric hearing aid verification best practices.

Design: A retrospective analysis uncovered patterns of best practice utilization, deviations, and regional variations, aiming to identify factors influencing early intervention for children with hearing impairments. Such insights would empower organizations like EHDI, ASHA, and AAA to address shortcomings in the current implementation of these best practices. Data were extracted from the EHDI-PALS survey responses, specifically focusing on pediatric amplification fitting and verification best practices.As of January 19, 2023, 1,554 facilities across the United States had completed the EHDI-PALS Facility Survey and were registered within the EHDI-PALS system. In 2017, Chung and colleagues developed a comprehensive questionnaire comprising 68 questions for the EHDI-PALS survey. Nationwide pediatric hearing facilities within the EHDI-PALS system were annually prompted to update their information, and the most recent survey data was extracted for analysis.

Results: Hearing Aid Dispensing to Children Under 6 Months: Eight states (Rhode Island, West Virginia, South Dakota, Kansas, New Mexico, Montana, Hawaii, and Washington) reported pediatric clinics dispensing hearing aids to children from birth to six months. The median state, Tennessee, had over 80% of its clinics providing this service, while Vermont had the lowest rate at 50%.Usage of RECD for Verification: Twenty states had 100% of clinics reporting a use of Real-Ear-to-Coupler Difference (RECD) for hearing aid verification. The median state, Michigan, had a usage rate of approximately 95%, while New Hampshire, West Virginia, and Montana had the lowest RECD usage rates at around 65%.Evidence-Based Fitting Formulae: 74.5% of states' pediatric audiology clinics (38 out of 51) consistently used evidence-based prescriptive fitting formulae when programming hearing aids for children. Some states exhibited usage rates less than 100%, including Texas, Virginia, Pennsylvania, Arizona, Georgia, Florida,

New York, Utah, Iowa, Maine, Mississippi, Wyoming, and Louisiana, with Louisiana having the lowest usage rate at approximately 80%.

Conclusions: This study provides an analysis of the adoption of best practices in pediatric hearing aid fitting, verification, and validation across 1,115 pediatric audiology facilities in the United States. Over 82% of pediatric clinics nationwide adhere to best practices recognized by the American Academy of Audiology (AAA), indicating widespread adoption throughout the country.However, further investigations are necessary to identify specific barriers to providing hearing aids for children under six months of age. Addressing these issues will enhance access to pediatric audiological services. This study serves as a valuable resource for organizations and policymakers aiming to improve early intervention efforts for children with hearing loss.

Category: Hearing Technology / Amplification

Poster #: 224

Investigations of Ear Tip Performance, Perceptions, and Experiences

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Objectives: Audiologists rely on third-party manufacturers to supply custom ear molds and hearing aid parts, which can create unintended barriers for patients pursuing care. The advancement of 3D printing technology, standardly used in the hearing health industry, has made it accessible for local clinical settings. This study aims to compare in-house 3D printed ear molds to professionally manufactured ear molds in a group of normal hearing individuals. The research involves comparing the production, physical, objective acoustic, and subjective comfort measures between professionally-made ear molds and in-house 3D printed ear molds. Implementing 3D printing locally could reduce geographic barriers, time, and costs for patients pursuing hearing healthcare.

Design: A randomized controlled, three-arm, cross-over trial will be conducted. Participants, aged 18-89 years, with normal hearing thresholds (≤ 25 dB HL) from 250 to 8000Hz will be recruited for this study. Additional inclusion criteria includes English as primary spoken language, no history of learning disability or cognitive impairment, and no history of neurological impairment or head injury. There are three phases of this study. The first session involves obtaining informed consent, ensuring potential participants meet eligibility criteria, and taking a custom ear impression of one ear. Next, ear impressions are 3D scanned, edited into an ear mold, and then 3D printed. The original ear impression will then be sent to a professional third-party manufacturer to fabricate a control ear mold. Participants will also be randomly assigned to one of three study arms, each with a different initial ear mold material type. Lastly, participants will be fit with each ear mold attached to a BTE hearing aid and production measures, objective acoustic measures, objective physical measures, and subjective comfort ratings will be collected. Protocol was approved by the IRB and is registered on clinicaltrials.gov (NCT05725824).

Results: Data collection is in progress and near completion. The main statistical analysis includes a repeated measures, within-group, ANOVA. A power analysis using G*Power 3.1 revealed that a sample

size of 17 to 26 subjects will provide 80-95% power to detect a medium effect size of 0.55 for Cohen's D using a .05 alpha level.

Conclusions: Three-dimensional printing has been standardly used by manufacturers for decades, however its adoption and implementation has not reached the local clinical level. This is not the case for dentistry/orthodontics, which has widely adopted and successfully implemented 3D printing technology to make custom mouth guards, retainers, and surgical guides for their clients in-house. This technology employed in a local audiology clinical setting has the potential to help reduce aspects of hearing healthcare disparities related to geographic barriers, time, and cost. Findings may lead to a novel method of hearing healthcare delivery that has the potential to increase overall hearing health care accessibility, generate an additional revenue source for audiology clinics, and create new telehealth applications for marginalized populations worldwide.

PEDIATRIC AUDIOLOGY / OTOLOGY

Category: Pediatric Audiology / Otology

Poster #: 225

Narrative Coherence and Wellbeing in Hearing Parents of Cochlear-Implanted Children

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Objectives: This study aims to explore the associations between the coherence of narratives gathered from hearing parents of pediatric cochlear implant (CI) users and their psychological wellbeing.

Design: Thirty hearing parents of children with CIs in the United States participated in this qualitative study of narrative sensemaking. All parents were fluent in spoken English, reported typical hearing and cognition, and had a child no older than 5 years with at least 3 years of CI experience. Parents were prompted to share stories of their early experiences as a parent of a child with hearing loss who uses CI(s).

Results: We are currently in the process of completing data collection and analysis. We predict that variations in narrative coherence will yield insight into the parents' psychological wellbeing. This hypothesis is based on previous research that showed individuals' narratives coherence is related to their wellbeing, with higher coherence being positively correlated with higher levels of wellbeing.

Conclusions: This study underscores the significance of narrative sensemaking when it comes to better understanding the experiences of hearing parents of children with CIs. Our potential findings will ideally highlight the fact that supporting and encouraging parents' narrative sensemaking can have far-reaching implications for parental wellbeing-particularly in the context of pediatric hearing healthcare.

Category: Pediatric Audiology / Otology

Poster #: 226

Adaptation of a Rural School-based Telehealth Hearing Screening Program

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Objectives: Childhood hearing loss is a widespread manifestation of health inequity. Hearing loss particularly impacts children in underserved communities, such as those in rural Kentucky and Appalachia. When inadequately addressed, hearing loss leads to lifelong cognitive, social, and economic consequences. State-mandated, annual hearing screening is one avenue to identify a potential hearing loss in rural children. In Kentucky, the protocols and diagnostic tools used for annual screening vary widely between communities. Our hypothesis was that the current screening protocols do not adequately refer children that do not pass their annual hearing screening to diagnostic services. We also predict that there are significant barriers to efficient diagnostic evaluation when hearing loss is identified through the annual screening. In Northern Alaska, our co-investigators previously demonstrated a telehealth screening model that significantly reduced rates of loss to follow up and time to evaluation for children that did not pass their annual hearing screening. This protocol included comprehensive hearing screening and telehealth evaluation by an audiologist for geographically remote children. Their intervention required adaptation to the context of Kentucky public schools and healthcare systems, which vary on both geographic and population levels from rural Alaska. The evidence-based ADAPT-ITT model served as a framework for utilizing qualitative data to guide adaptation of an established screening and telehealth protocol into a novel context.

Design: In 31 qualitative interviews, our team sought feedback from key stakeholders on four components of the proposed intervention. These components included school hearing screening, telehealth specialist evaluation, communication between schools and healthcare providers, and communication between schools and families. Stakeholders included educators, healthcare personnel, and parents. Participants were intentionally selected from the 14 partner counties serving as future implementation sites for the adapted intervention. Participants were also referred from our Community Advisory Board.

Results: The interviews were analyzed through rapid qualitative analysis, including use of Atlas.ti and generation of a summative matrix for extraction of key themes. Application of the ADAPT-ITT framework served to guide the role of qualitative data in shaping adaptations to the established intervention from Alaska into a novel context of rural Kentucky. The phases of the ADAPT-ITT model include: assessment, decision, adaptation, production, topical experts, integration, training, and testing. Primary themes included identifying the standard processes of annual screenings in each school district, perceptions of parental knowledge and responsibility, sources of miscommunication between vested parties, and limitations to communication of protected health information. Barriers were then summarized in three primary domains: school, parent, and healthcare.

Conclusions: Data and themes extracted from our qualitative interviews were formative in the production of the intervention protocols, including a 5-minute mobile health hearing screening that includes pure

tone assessment, otoacoustic emissions, otoscopic view, and tympanometry. This health information will be communicated asynchronously on a cloud-based platform to regional, state-funded clinics. This varies from a traditional telehealth evaluation system. In conclusion, our work illustrates the value of incorporating qualitative data into mixed methodology projects as a pathway to ensure that the on-the-ground barriers for underserved populations are adequately addressed in translational hearing research.

Category: Pediatric Audiology / Otology

Poster #: 227

Ecological Momentary Assessment in Adolescents with and without Hearing Loss

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Objectives: The primary aim of this presentation is to compare listening habits between adolescents with hearing loss and adolescents with typical hearing using Ecological Momentary Assessments (EMA). Questions were presented to adolescents that targeted areas including listening activity (e.g., what they are listening to), location, presence of background noise, listening effort, and listening fatigue. Another aim includes determining which daily environments and factors are associated with high levels of listening effort and fatigue. A final aim is to identify listening or environmental factors that influence hearing aid use in adolescents with hearing loss. Our hypothesis is that adolescents with hearing loss experience higher levels of listening effort and fatigue than their peers with typical hearing. We also hypothesize that listening effort and fatigue levels will be greater in environments with higher noise levels and more demanding listening tasks. Another hypothesis is that adolescents with hearing loss will exhibit less active daily listening environments than their typical hearing counterparts. Finally, we hypothesize that more often and more difficult listening environments will result in higher hearing aid use in adolescents with hearing loss.

Design: Participants included 21 adolescents (14-18 years old) from our database who were currently enrolled in a longitudinal study on outcomes of children with hearing loss. Eleven adolescents with hearing loss (average better-ear PTA = 44.5 dB HL) participated. All participants with hearing loss wore hearing aids. The remaining 10 participants had typical hearing. Participants completed the EMA study during the school year or during summer break, with 15 participants completing the study in both seasons. Each participant was provided with an Android smartphone. EMA surveys were delivered to the participants eight times a day for seven days via the smartphone. Each day included one morning survey, six daytime surveys, and one night survey. Each survey included questions that addressed areas such as hearing aid use (for those adolescents with hearing aids), current location, current listening activity, presence of background noise, general fatigue, listening effort, and listening fatigue A training session was completed with each participant at the beginning of their survey week and an exit interview was

completed at the end of the week. The feasibility of using EMA with adolescents with and without hearing loss was determined before analyzing further data.

Results: Compliance for completion of notified surveys by the adolescents was high (ave = 74.87%). There was no significant difference between the adolescents with hearing loss and the adolescents with typical hearing in terms of compliance of survey completion. Data collection is completed, but will be further analyzed before the presentation deadline. We will use a linear mixed model with fixed factors of hearing status, season of survey completions (summer or school year), and study session (first session or second).

Conclusions: EMA is a viable approach to collecting real-time data on the listening experiences of adolescents with and without hearing loss.

Category: Pediatric Audiology / Otology

Poster #: 228 **T35 Research Trainee Poster**

Cognition, Spectral Resolution, and Speech in Noise Perception in Children

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Objectives: The purpose of this project was to evaluate the interplay between spectral resolution, cognition, and speech recognition in background noise for children with typical hearing acuity. We hypothesized that 1) as age increases, performance on the cognitive and spectral resolution tasks will improve, and 2) children with higher cognitive skill development and lower spectral ripple depth thresholds will demonstrate better understanding of speech in background noise.

Design: Thirty-six children aged 6-12 years-old with typical neurocognitive development and hearing acuity participated in this study. All participants had behavioral air conduction thresholds ≤ 15 dB HL across octave frequencies 250-8000Hz. Each participant was administered three cognitive tasks from the Psychology Experimental Building Language (PEBL) software. This included the Flanker task, Corsi-blocks tapping task, and Match-to-Sample task. To assess spectral resolution, participants completed a 3 Alternative Forced Choice spectral ripple depth discrimination task at two static ripple densities of 2 and 4 Ripples Per Octave. Both density conditions used a 2000 Hz center frequency with local modulation, and a broadband carrier. Two conditions of a sentence recognition task with Bamford-Kowal-Bench sentences in two-talker maskers were used to assess speech recognition in noise. SNR50 thresholds were obtained using reverberant and non-reverberant stimuli in two collocated conditions presented in the sound-field. Task order was randomized by category, and density condition in the spectral resolution task.

Results: The interaction effect between age and density condition on SRD thresholds was significant. There was no relationship between age and SRD threshold in the 4 RPO density condition, however thresholds increased by nearly 1 dB per year of age in our sample in the 2 RPO condition. Preliminary linear mixed effect model results showed no relationship between spectral ripple depth thresholds and

SNR50 thresholds after controlling for age in our sample; however, age was found to co-predict both spectral ripple depth and SNR50 thresholds. Additionally, no relationship was observed between either the composite cognitive measure and SRD thresholds, nor the composite measures and SNR50 thresholds. When assessed individually, there was a meaningful effect of the Flanker task identified, accounting for nearly 1 dB per standard deviation of SRD and SNR50 thresholds.

Conclusions: Spectral resolution and speech in noise abilities both improve as children age, but the underlying mechanisms for these improvements may differ. Assessing how these mechanisms interact in a group of typically hearing and neurocognitively developing listeners can inform how we interpret speech processing differences in children with varying degrees of hearing acuity in clinical settings.

Category: Pediatric Audiology / Otology

Poster #: 229 **Mentored Student Research Poster Award**

Effects of Age and Developmental Disability Status on Behavioral Assessment

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Objectives: Because the audiogram is recognized as the gold-standard hearing assessment for infants (> 6 months) and children, obtaining accurate thresholds is often the cornerstone upon which timely diagnosis and access to interventions is built. However, the developmental demands of behavioral methods are often misaligned with the developmental abilities of children with diverse or complex developmental profiles. The purpose of the present study was to evaluate behavioral assessment practices during the first audiogram encounter as a function of child age and developmental disability status.

Design: We analyzed audiogram and diagnosis data from 121,186 children (4 months to 19 years) who received hearing healthcare at three hospitals in the United States. Based on their first audiogram encounter, we counted the total number of thresholds obtained and the type of thresholds (i.e., ear-specific air conduction; soundfield air conduction; bone conduction). Children were classified as having a developmental disability if they had an ICD 9/10 diagnosis code of autism spectrum disorder, cerebral palsy, Down syndrome, or intellectual disability (9% of sample). A general linear model was constructed to determine how the number of thresholds changed based on age and developmental disability status. Binary logistic regression models were used to determine the odds ratio (OR) for not having ear-specific, air conduction thresholds or bone conduction thresholds based on developmental disability status while accounting for age, organization, sex, race, and ethnicity.

Results: The linear model indicated that 64% of the variability in the number of thresholds collected could be explained based on child age, developmental disability status, organization, and sex ($p<0.001$). Except for the youngest age brackets (<2 years), pairwise comparisons revealed that children with developmental disabilities had significantly fewer thresholds than children in the comparison group of similar age (all $p<0.05$). For the first audiogram encounter, no ear-specific, air conduction thresholds were recorded for 49.0% of children with developmental disabilities and 33.6% of children in the

comparison group (p< .001; OR = 5.37; 95% confidence interval (CI) = 5.00, 5.75). For children who were ultimately classified as having reduced hearing (N = 24,166), bone conduction thresholds were not obtained at the first audiogram encounter for 50.5% of children with developmental disabilities and 38.9% of children in the comparison group (p< .001; OR = 2.97; CI = 2.66, 3.31).

Conclusions: Results from this study indicate substantial differences for the quantity and quality of behavioral thresholds collected based on age and disability status. The findings highlight an urgent need for behavioral assessments that meet the needs of children with developmental disabilities and the creation of assessment protocols tailored to specific developmental disabilities.

Category: Pediatric Audiology / Otology

Poster #: 230 **Mentored Student Research Poster Award**

Audiometric Profiles of Children with Sound Sensitivity and Tinnitus

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Objectives: Approximately 3-17% of children experience hyperacusis (sound sensitivity) and 6-42% experience tinnitus (ringing in the ears). Whereas hyperacusis and tinnitus often co-occur in adults, little is known about this pairing and its pervasiveness in children. Moreover, the audiometric profiles of children who experience hyperacusis and/or tinnitus are not well-characterized. The purpose of this study was to assess the prevalence of sound sensitivity and tinnitus in pediatric patients aged 5-17 years who were seen at the Callier Center for Communication Disorders in Dallas, TX. We also sought to characterize the relationships among sound sensitivity, tinnitus, audiometric profiles, and demographic characteristics (e.g., age, biological sex, and co-morbid medical and/or behavioral conditions) in these children.

Design: We retrospectively analyzed data from 126 pediatric patients (75 boys, 51 girls) between the ages of 5 and 17 years who visited the Callier Center for Communication Disorders from 2019 to 2022. Each patient file indicated whether the child experienced sound sensitivity and/or tinnitus. Additional case history information included demographics, hearing-related concerns, and relevant medical history. One hundred nineteen files contained comprehensive audiometric data.

Results: Approximately 12.9% of the children reported sound sensitivity and 7.9% reported tinnitus (2.4% unilateral tinnitus and 5.5% bilateral tinnitus). Three children (2.4%) reported both sound sensitivity and tinnitus. More boys than girls reported sound sensitivity (69.8% versus 31.2%, respectively), whereas an equal number of boys and girls reported tinnitus (50.0% each). Most children with sound sensitivity (75.0%) and/or tinnitus (80.0%) had hearing within normal limits bilaterally at standard audiometric frequencies (i.e., thresholds<= 25 dB HL at octave intervals between 250-8000 Hz). The remaining children with sound sensitivity (25.0%) and tinnitus (20.0%) had asymmetric hearing loss (i.e., unilateral hearing loss or bilateral, asymmetric hearing loss). Of the three children who had both sound sensitivity and tinnitus, two (66.7%) had normal hearing and one (33.3%) had asymmetric hearing loss. A high proportion of children with sound sensitivity had difficulty in school (56.3%), speech or

language concerns (50.0%), behavioral issues (37.5%), and mental health concerns (25.0%). Conversely, children who only reported tinnitus did not indicate any of the preceding conditions, except for one child with mental health concerns.

Conclusions: Most children who report sound sensitivity, tinnitus, or both conditions upon audiological evaluation present with normal hearing or asymmetric hearing loss. These findings align with recent published work showing that 45.2% of adults with hyperacusis and 43.7% with tinnitus have normal hearing, as well as both overt and subclinical hearing asymmetries (20.9% and 13.2%, respectively). Future work will investigate the role of loudness perception and physiological responses to sound in assessing and monitoring children who have subjective hearing disorders lacking measurable hearing loss. Moreover, the high prevalence of educational, behavioral, and mental health concerns in children with sound sensitivity illuminates the importance (or necessity) of interdisciplinary management for pediatric hyperacusis.

Category: Pediatric Audiology / Otology

Poster #: 231

Examining Device Use using Ecological Momentary Assessment in Spanish-Speaking Children

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Objectives: Consistent device use is a key aspect of rehabilitation in children who are hard of hearing (CHH), yet less is known about daily device use in bilingual CHH. Previous work suggests Spanish-English bilingual CHH use their HAs for fewer hours compared to monolingual children. However, measuring device use in children requires a retrospective questionnaire or a laboratory visit to collect data from the child's devices (i.e., datalogging). These measurements also lack the ability to link device use to other events co-occurring in the home (e.g., language environment, barriers to non-use). Ecological momentary assessment (EMA) could allow the sampling of real-time device wearing behaviors outside of the laboratory, providing a clearer picture of device use in bilingual CHH in their daily environments. The purpose of the project was to determine feasibility of using EMA for assessing device use in Spanish-English bilingual CHH in their daily environments.

Design: This feasibility study included Spanish-English bilingual children who use bilateral hearing aids and/or cochlear implants and their caregivers. The experiment included an initial in-person baseline session, one week of EMA reporting, and a final in-person post-study session. At the baseline session, caregivers completed questionnaires that included information about demographics, language history, and hearing history. We also collected average hours of device use from the child's devices using datalogging and audiologic information about aided and unaided hearing. For the following week, caregivers received daily text messages at regular time intervals prompting them to answer a short survey via REDCap. The questions ask the parent to report a) if the child is wearing their HAs; b) if not, reason for non-use; c) the daily environment they are currently in; and d) what language(s) they are

currently listening to and speaking. At the end of the week, parent/child participants return for a second in-person appointment to collect datalogging to validate the EMA responses and for a semi-structured interview with the caregiver about device use practices, home language environment, and barriers to audiological care and counseling.

Results: Data collection is underway, but preliminary data show that parents can complete multiple surveys at home using EMA. Data collected from these surveys suggest that device use estimated via EMA approximates datalogging estimates. Parents are able to report in real time the reasons for non-use (e.g., nap time, sports). This method also allows the simultaneous assessment of device use and language use, which is key in bilingual homes where Spanish and English may be used separately or simultaneously while the child's device is either in use or off.

Conclusions: EMA provides an innovative methodological tool for understanding CHH outside of a clinical or laboratory setting. This tool may provide increased ecological validity and accessibility of participating in research for individuals who may experience barriers in participating in lab-based research studies. Future studies using this procedure can help us better understand device use and barriers to use in groups underrepresented in hearing science research.

SPEECH PERCEPTION

Category: Speech Perception

Poster #: 232

Extended-High-Frequency Cues for Spatial Speech Perception: Head Orientation and Reverberation

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Objectives: Emerging evidence suggests that extended-high-frequencies (EHFs; > 8 kHz) contribute to speech-in-speech recognition in controlled laboratory settings. In this study, we explore whether these benefits generalize to more realistic listening conditions, i.e., in the presence of reverberation and with talkers facing different directions.

Design: Listeners were adults ages 19-55 with hearing thresholds< 25 dB HL from 250-8000 Hz, and a range of thresholds in the extended range of 10-20 kHz. Listeners repeated target Bamford-Kowal-Bench (BKB) sentences produced by a female talker and presented over loudspeakers in an anechoic chamber (0°). Masker stimuli were segments from non-scripted narrative recordings produced by two additional female talkers, presented from non-target loudspeakers (±45°). Target-to-masker level ratio (TMR) was varied adaptively to estimate speech reception threshold (SRT) from psychometric functions (proportion

of words correct vs TMR). Listeners were tested in eight spatially separated target-masker configurations that manipulated masker facing direction (0° vs 90°), spectrally flat reverberation (anechoic vs 400 ms RT60), and EHF energy content (full band vs 8-kHz lowpass filtering).

Results: Performance was better in an anechoic environment as compared to a reverberant environment. Measurable head-orientation benefits were limited to anechoic conditions, with better SRT for non-facing maskers. Reverberation appeared to eliminate this benefit. Effects of EHF energy were mixed and may depend on listeners' auditory sensitivity to those cues.

Conclusions: Clear impacts of reverberation on performance were observed in all conditions. Maskers facing away from the listener proved to be less detrimental except when reverberation was present. Reverberation had objective impacts on listener performance and subjective impacts on task difficulty and fatigue according to listener reports. Specific benefits of EHF were not observed in these challenging listening conditions, but may depend somewhat on listener and/or task characteristics.

Category: Speech Perception

Poster #: 233 **Mentored Student Research Poster Award**

Extended-High-Frequency Hearing Contributions in Speech-in-Noise Perception in Cystic Fibrosis Patients

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Objectives: Patients with Cystic fibrosis (CF) often undergo treatment with aminoglycosides (AGs) to manage recurrent pulmonary infections. Chronic use of AGs leads to complex cochlear damage affecting inner and outer hair cells, stria vascularis, and spiral ganglion neurons. Histopathological examinations of human temporal bones indicate that damage is typically greatest in the basal cochlear region, which encodes high-frequency hearing, but is also present in apical regions. Extended-high-frequency hearing

loss (EHFHL; 9-16 kHz) is one of the first findings occurring after starting AG treatment. Recent evidence suggests that EHFHL is associated with impaired speech-in-noise (SiN) perception and could be an early marker for subtle damage within the standard frequency (SF; 0.25-8 kHz) range. The present study aimed to investigate this hypothesis in children and young adults with CF. We hypothesized that SiN perception difficulties in individuals with CF are linked to combined cochlear and neural damage primarily in the EHF and more subtly in the SF range. This hypothesis can be assessed through three potential models: M1) a primary effect of EHFHL on SiN perception because of reduced audibility at EHFs; M2) a secondary effect of EHFHL on SiN perception due to reduced pure-tone sensitivity and transient-evoked otoacoustic emissions (TEOAE) in the SF range; and M3) neural damage as reflected by middle ear muscle reflexes (MEMRs) that are related to impaired SiN performance.

Design: This study included 184 subjects, comprising 101 CF and 83 age-matched individuals without CF (NCF). Assessments included hearing threshold level using pure-tone audiometry (PTA) testing at SF and EHF, the Bamford-Kowal-Bench (BKB)-SIN test for SiN perception, double-evoked TEOAEs with chirp stimuli from 0.71 to 14.7 kHz, and measurements of ipsilateral and contralateral wideband MEMR thresholds.

Results: M1) EHF damage (measured by PTA and TEOAE) was significantly associated with impaired SiN perception for the CF group. In contrast, EHF damage in the NCF group did not correlate with impaired SiN perception. M2) greater SF damage (measured by PTA and TEOAE) was evident in CF ears with EHF threshold elevation and was also correlated with impaired SiN performance. However, SF hearing were not significant predictors of SiN performance in the NCF group. M3) CF patients with normal EHF hearing exhibited significantly lower (better) MEMR thresholds than those experiencing EHFHL, particularly when compared to the NCF group. Moreover, lower MEMR thresholds were related to better SiN performance in both the CF and NCF groups

Conclusions: Main findings showed that both SF and EHF hearing damage were associated with impaired SiN performance in individuals with CF. Our findings suggest that multiple mechanisms (both sensory and neural) are involved in impaired speech perception in noise. These results are consistent with histopathology results in temporal bone studies of CF individuals treated with AGs and animal studies of AG exposure. A deeper understanding of auditory and communication abilities in the CF population could direct future repair strategies or preventive treatment for this population.

Category: Speech Perception

Poster #: 234

Children's Sentence Perception in Various Masker Types Under Reverberation

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Objectives: To investigate the developmental trajectory of sentence recognition in multiple types of speech and non-speech maskers in free-field and realistic reverberation settings. We hypothesize that normal-hearing children's speech perception improves during school-age years, but at different rates depending on the masker type. In addition, children may reach adult-like speech-in-noise or speech-in-

speech perception more slowly in realistic reverberation than in free-field. In our study, the effect of reverberation on informational masking is assessed across school-age children and compared with adults.

Design: Forty-one children from 6-16 years old and 22 young adults with normal hearing completed the study. Participants repeated back open-set AuSTIN sentences in quiet and in five masker types with increasing informational masking: (1) speech-shaped noise, (2) modulated speech-shaped noise, (3) reversed two-talker English, (4) two-talker French and (5) two-talker English maskers. The same-sex speech and non-speech masker conditions were created from the same female talker. Speech reception thresholds (SRTs) were measured adaptively at 50% keyword accuracy. The SRTs were repeated in three simulated acoustic conditions using auditory virtual reality: (1) free-field as control, (2) low-reverberation from a well-designed classroom with 0.4 s reverberation time (RT), and (3) high-reverberation from a large lecture hall with 1.2 s RT. Informational masking was defined as the SRT increase of each masker type from SSN for each participant, and examined across age and acoustic conditions.

Results: Children experienced 4-6 dB SRT improvement in quiet per year of age between 6-16 years old. For speech perception in maskers, the rate of SRT improvement was slower for non-speech maskers (i.e., unmodulated and modulated speech-shaped noise) than for speech maskers. Reverberation resulted in higher SRTs for speech perception in quiet by 8-14 dB and for speech perception in maskers by 3-6 dB on average. Contrary to all children and adults achieving negative SRTs in the anechoic condition, adding reverberation resulted in more children requiring a positive SRT to complete the task. Masker type had a stronger influence than reverberation on the rate of SRT improvement. Informational masking was not observed for modulated speech-shaped noise but for all three speech maskers, and at greater levels under high-reverberation than in low-reverberation or free-field. Informational masking improves over time for children and acoustic conditions, reaching maturation in late adolescence.

Conclusions: Reverberation poses a challenge for children to recognize sentences in quiet and in various masker types. Informational masking is experienced by children and is greater with increasing reverberation, particularly when the two-talker same-sex masker was in the language they understood. The developmental trajectories of speech perception in quiet and in noise as well as informational masking in various acoustic conditions were demonstrated.

Category: Speech Perception

Poster #: 235

Age and Hearing Effects on Cognition and Speech-in-Noise Recognition

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Objectives: Age-related hearing loss is commonly identified as the primary factor contributing to the difficulties encountered by older adults in understanding speech in background noise when compared to young adults. Nevertheless, the variability in speech recognition capabilities in noisy environments among older and younger listeners exceeds predictions based solely on their pure-tone audiometric thresholds. Research suggests that various cognitive functions, including executive functions and working memory, significantly contribute to explaining this variability. Thus, the objective of the present study was to determine the relationship between different cognitive tasks and speech-in-noise recognition as a function of age and hearing loss. In line with the findings from previous studies, our hypothesis posited that a stronger correlation between cognition, especially working memory, and speech-in-noise recognition would manifest in both ONH and OHI groups compared to YNH. Additionally, we expected this correlation to be particularly heightened in the OHI group compared to the ONH group.

Design: Three groups of participants were enrolled in the study: young adults with normal hearing (YNH) (n = 8; age = 20-37 years), older adults with normal hearing (ONH) (n = 9; age = 62-77 years), and older adults with hearing impairment (OHI) (n = 10; age = 60-78 years). Cognition was tested using the Digit Span Forward & Backward, Stroop, and Trail Making Test - Part B. Speech-in-noise recognition abilities were tested using the QuickSIN and the Listening in Spatialized Noise-Sentences test (LiSN-S). The Digit Span serves as a widely employed indicator of working memory capacity, while the Stroop and Trail Making Test are both assessments of diverse executive functions such as selective attention, processing speed, and cognitive flexibility.

Results: As expected, the YNH group performed significantly better than the OHI group for both speech-in-noise tests. In addition, ONH participants generally performed better than OHI participants. Main effects of group on cognitive tests were also found with YNH participants generally performing better than older groups. However, contrary to our expectations, a significant correlation between the Digit Span score and QuickSIN test performance was observed solely within the YNH group.

Conclusions: Results from this study generally support our current understanding of the effects of age and hearing loss on cognition and hearing: that cognition and speech recognition in noise decline with age. However, significant correlations between cognition and recognition only for the YNH group suggest that cognition's role in speech-in-noise recognition may be heavily dependent on the specific tests used.

Poster #: 236

Engaging Stories for the Study of Attention and Audition: An Introduction to the ESSAA Database

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Objectives: The cognitive effort that individuals are willing to expend on difficult tasks is influenced by the extent to which they feel motivated to perform well. Such motivation can be induced extrinsically using rewards like financial incentives or might be evoked intrinsically by designing research protocols that are inherently interesting to participants. In light of recent trends towards using naturalistic,

continuous speech for the study of hearing and attention, the present study aimed to characterize a selection of short stories with respect to the degree of engagement that they induce.

Design: Twenty short written works were selected from the public domain whose spoken lengths were between 10 and 20 minutes. To gauge interest in the works independently of narrator style or audio quality, participants read the written stories and then completed Kuijpers' Story World Absorption Scale (SWAS). The SWAS is a 20-item instrument that measures reader engagement along four dimensions: transportation, emotional engagement, mental imagery, and attention, as well as producing a total score. To support auditory research, interest in a selected narrator's reading style was also gauged using a single Likert scale item in response to a 30-second excerpt of the audio story, drawn from the LibriVox platform. Attention towards the stories was also verified via 10-item factual quizzes administered prior to the SWAS. A total of 930 ratings were obtained from North American participants aged 16 - 25 via an online survey, across all twenty written works.

Results: Overall, accuracy on the factual quiz tended to correlate with absorption scores ($rho = 0.41$, $p < .001$), indicating that participants who found a given story less engaging retained less information from that story. Narrator interest ratings, by contrast, did not correlate with absorption ($rho = 0.10$, $p = .012$), which is unsurprising given that audio recordings of the narrations were not heard until after the absorption survey was complete. Absorption scores varied considerably between works, with some producing significantly less engagement than others. Interest ratings for the narrators' reading styles, by contrast, rarely differed significantly.

Conclusions: These reports suggest that, while the choice of story is important in the design of an engaging study, the choice of narrator is relatively less important. Our results also stress the non-independence of story engagement and accuracy on the factual quiz, indicating that caution is warranted in the use of such quizzes to verify attention towards uninteresting narrative stimuli. These absorption and narrator interest scores, as well as the factual quiz items used for verifying attention towards the stories, comprise the ESSAA database, which is intended to help researchers select engaging materials for their own research.

Category: Speech Perception

Poster #: 237

The Role of Suprasegmental Cues During Speech Recognition with Speech Maskers

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Objectives: Speech in real-life communication carries both segmental and suprasegmental information. Suprasegmental cues facilitate speech perception by allowing anticipation of upcoming speech and parsing of the speech stream, leading to more accurate understanding and decreased processing time and effort. It is unclear, however, whether suprasegmental cues affect speech perception in noisy environments. Without this knowledge, real-life communication challenges may be under- or over-estimated, resulting in suboptimal ecological validity of clinical assessments. Therefore, the first objective of this study was to examine the effect of suprasegmental cues on speech recognition accuracy and

listening effort in speech maskers. Concerning the effect of speech maskers, the second objective was to examine whether the suprasegmental effect is modulated by the informational masking mechanism from the intelligible speech masker. Built on the literature suggesting suprasegmental cues facilitate higher-level processing of speech, it is hypothesized that listeners rely more on suprasegmental cues in intelligible speech maskers due to the lexical interference from the masker.

Design: Speech stimuli consisting of linguistically controlled sentences were developed and recorded based on prior literature examining suprasegmental effects. They were temporarily ambiguous early closure sentences such as "While the parents danced the child sang a song..." Each sentence was produced in two suprasegmental conditions: facilitative and neutral. The facilitative condition contains suprasegmental cues that supports interpretation of the sentence. The neutral condition has a relatively flat, albeit natural, suprasegmental contour. Younger adults (18-35 years) with normal hearing listened to each sentence embedded in either original 2-talker speech masker or time reversed control condition. The signal-to-noise ratio was fixed at -5 dB SNR based on piloting to achieve an overall intelligibility of 80%. After each sentence, participants repeated back what they heard in the sentence. Recognition accuracy and pupil dilation during the recognition task were analyzed as the dependent measures for performance and listening effort, respectively.

Results: Results to date showed the participants had better recognition performance with facilitative than neutral suprasegmental cues. Peak pupil dilation at the end of sentences also indicated reduced listening effort associated with the facilitative suprasegmental cues. Further, suprasegmental effects were modulated by the intelligibility of the speech maskers, with larger benefits of suprasegmental cues when the masker was intelligible.

Conclusions: The results suggest that suprasegmental cues impact speech recognition in speech maskers. This work extends the current theoretical understanding of speech perception under adverse conditions to include the role of suprasegmental cues. Clinically, these findings highlight the importance of using more realistic material that necessitates listeners' use of suprasegmental cues in clinical speech assessment.

Category: Speech Perception

Poster #: 238 **Mentored Student Research Poster Award**

"Visual World Paradigm" Based Assessment of Spatial Release from Masking

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Objectives: Spatial separation of a target speech source from a competing speech source (masker) improves the accuracy and perceived ease with which a typically hearing listener can identify the target. Under these experimental conditions, behavioral measures like percent correct scores are not designed to also provide insight into the momentary development of the decision-making process that produces the ultimate perceptual judgement. For this study, we employed the "visual world paradigm" wherein

participants' eye-gaze was monitored as they searched among on-screen images corresponding to the speech target embedded in a speech masker following presentation of the auditory stimuli. The objective of this study was to establish normative ranges for the effects of target-masker configuration and signal-to-noise ratio (SNR) on the events unfolding over the time course of target determination.

Design: Target and masker stimuli were CRM sentences produced by one of four male talkers. These sentences share identical syntax, varying only in the "call sign" (e.g., "Baron", "Hopper"), color, and number they include. The target call-sign was always “Baron,” but the masker call-sign varied randomly across trials, and the masker sentence was always spoken by a talker different from the one speaking the current target sentence. Target stimuli were played at 65 dBA via loudspeakers located at +/- 90º azimuth. They were presented in quiet or with a co-located or spatially separated speech masker, and signal-to-noise ratio (SNR) was varied. Participants were instructed to identify the image depicting the target among four choices on a computer monitor. The screen was split into four equal quadrants, each containing the target number in the target color (target), the masker number in the masker color (incongruent foil), the target number in the masker color (partially congruent foil), or the masker number in the target color (partially congruent foil). The design includes twenty-five NH adults.

Results: As expected, participants identified a speech target presented in quiet more successfully than with a masker. In addition, release from masking was evidenced by greater accuracy for target speech in the separated compared to the co-located target-masker configuration. Across all trials, duration was similar for all target-masker configurations and SNRs. Even when performance was equated (i.e., when comparing only trials with successful target identification), listeners fixated on non-target candidates most in the co-located target-masker configuration. Additionally, there was a trend toward a greater overall number of fixations for speech targets presented with a masker.

Conclusions: This work is designed to characterize perceptual uncertainty in auditory processing of target speech, and the impact of providing spatial cues that facilitate separation from maskers. By monitoring how fixations and saccades change across these listening conditions, we can study the relationship between auditory uncertainty and target identification accuracy. The use of an online eye tracking measure has the potential to reveal differences in auditory uncertainty that occurs across conditions that yield similar target identification accuracy. This study, in normal hearing listeners, will serve as a foundation for upcoming work investigating how this decision-making process differs in listeners with bilateral cochlear implants, especially those with across-ear asymmetries.

Category: Speech Perception

Poster #: 239 **T35 Research Trainee Poster**

Speech in Noise as a Predictor of Subjective Listening Fatigue

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Objectives: Our research questions are as follows: 1.Can speech in noise word recognition accuracy predict levels of self-reported fatigue? 2.Does language comprehension ability predict levels of self-reported fatigue? We hypothesized that poorer word recognition accuracy and poorer language

comprehension abilities will be linked to higher levels of self-reported fatigue in children with hearing loss.

Design: This investigation was conducted as a part of the ongoing ELLA Study; Emergent Language and Literacy Development in Children with Hearing Loss, (RO1 DC17173 to Werfel and Lund). Data from 50 participants have been analyzed to date, from children with and without hearing loss, aged 7 to 12 years. The Functional Listening Evaluation was used to measure speech perception in background noise. Subjective listening fatigue was measured using two validated self-report surveys administered to both children and their parents: the Pediatric Quality of Life Scale (PedsQL), and the Vanderbilt Fatigue Scale Pediatric (VFS-P). Literacy was measured using the Clinical Evaluation of Language Function 5(CELF-5) and Woodcock Reading Mastery Test 3(WRMT-3).

Results: In both children with and without hearing loss, a significant correlation was observed between speech in noise understanding and VFS-P scores. CELF-5 Core Language Scores were found to be highly correlated with speech perception in both quiet and in noise.

Conclusions: Regardless of hearing status, a relationship exists between literacy, speech in noise understanding and self-reported mental fatigue induced by effortful listening. Speech in noise understanding and language comprehension could be used to identify children at higher risk of listening induced fatigue.

Category: Speech Perception

Poster #: 240

Extended-High-Frequency Cues for Speech Perception: Talker Head Orientation and Gender

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Objectives: Extended high frequencies (EHFs; >8 kHz) in speech provide beneficial cues for masked speech recognition, particularly when target talker EHFs remain unmasked. Owing to the directionality of EHFs in speech, EHFs remain unmasked when masker talkers are facing away from the listener while the target talker faces the listener. The EHF benefit for this scenario has been demonstrated using female speech. Since male speech has lower EHF levels than female speech, it is not clear whether EHF speech cues are audible and beneficial for male speech-in-speech recognition. Here we tested whether EHFs in male speech provide benefit for masked speech recognition.

Design: Subjects were young, normal-hearing listeners (≤20 dB HL at 250-8000 Hz, bilaterally). Speech recognition thresholds (SRTs) were measured using an adaptive procedure with a male target talker and a male two-talker masker. The target talker was located in front of the listener and always faced the

listener. Experimental manipulations included: facing vs. non-facing maskers (facing 90°), co-located vs. spatially separated maskers (±45° symmetric separation), and full-band speech vs. speech low-pass filtered at 8 kHz.

Results: The pattern of preliminary results is similar to female speech experiments previously conducted. Namely, spatial separation of target and maskers produced the greatest benefit. Non-facing maskers also provided a substantial talker head-orientation related (THOR) benefit. A small EHF benefit was observed in the co-located, non-facing masker condition, but this benefit was reduced in other conditions.

Conclusions: The EHF benefit for male speech-in-speech recognition may be similar to that previously demonstrated for female speech for young, normal-hearing listeners. Likewise, the THOR benefit is similar for male and female talkers. The EHF benefit is reduced when target and maskers are spatially separated. Whether elevated EHF pure-tone thresholds influence these effects remains to be seen. [Supported by NIH R01-DC019745]

Category: Speech Perception

Poster #: 241

Preliminary Data for an Adaptive Word-Recognition Protocol for Clinic Use

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Objectives: Quantifying how the word-recognition performance of a patient changes across a range of presentation levels is important for a variety of reasons. This project involves the development of a novel, adaptive word-recognition paradigm for generating psychometric functions as part of an audiological evaluation. The adaptive paradigm involves alternating two, 25- or 50-word lists between ears potentially over a 50-60 dB range from ~35- to ~85-dB HL in 10-dB increments; stopping rules can be incorporated. Only words missed at the previous lower presentation level are presented at the next higher level. The assumption is that, once a word is recognized correctly at a lower level, that word will be recognized correctly at subsequent higher levels. Experiment 1 evaluated whether this assumption was correct. Experiment 2 evaluated the practicality and accuracy of the adaptive protocol.

Design: Two groups of 24 young adults with normal hearing for pure tones participated. Six levels (6- to 36-dB HL) in 6-dB increments were tested. Both experiments, under computer control, presented a 50-word, NU-6 list (VA-1 female speaker) to one ear preceded by 3 familiarization words from a third list then switched ears and repeated the protocol with a second list. Next, the ear was switched and the protocol repeated at the next higher presentation level, etc. Each list was a unique randomization. Experiment 1 presented all 50 words to each ear/level combination, whereas Experiment 2, after the initial level only the words that were incorrect at the previous level were presented. The lowest level at which a word was recognized was considered the word-recognition threshold. The 25-word lists were defined as the odd and even numbered words from the 50-word alphabetized lists. In Experiment 1, immediately following the listening portion of the protocol, the subjects reported the test words that they remembered so as to informally evaluate learning effects.

Results: Experiment 1 scored the data two ways: (1) assumed data-assumed all responses were correct after the first correct response, and (2) raw data-traditional data based on the actual number of correct responses. The average agreement between the two scoring methods was 95.9% with the minimum (93.2% at 24-dB HL) and maximum (98.8% at 12-dB HL). On average, six words/list were remembered. Experiment 2 was scored based on the cumulative number of correct responses at each presentation level. The psychometric functions were essentially identical to the functions in Experiment 1 and to the functions for the same speaker from a 1990 study. Combined experimental results-(1) mean word-recognition thresholds ranged from 9.2-dB HL (dog) to 30.3-dB HL (join, came, rough); (2) word variability was greater than subject variability; (3) the overall mean inter-stimulus interval was 3.0 s, decreasing from 4 s (6-dB HL) to 2.5 s (36-dB HL); and (4) the 25-word functions closely corresponded to the parent 50-word functions.

Conclusions: The Experiment 1 data supported the assumption underlying the proposed adaptive word-recognition protocol. Experiment 2 demonstrated that the proposed adaptive protocol produces psychometric functions essentially identical to functions generated with complete lists presented at each presentation level.

Category: Speech Perception

Poster #: 242

Audiovisual Perception of Interrupted Speech by Non-Native Listeners

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Objectives: The purpose of this study was to determine the importance of visual cue during the perception of interrupted speech by non-native English listeners and to identify the role of working memory (WM) and vocabulary in audiovisual speech perception by non-native listeners.

Design: Participants included 30 native Mandarin speakers who learned English as a second language (L2). The listeners were between 19 and 41 years old (M=29.7 yrs, SD=6.1 yrs). The perceptual stimuli were noise-filled periodically interrupted (at 2.5 Hz) AzBio and QuickSIN sentences with or without visual cues that included a male speaker speaking the sentences. In addition to sentence perception, the listeners completed a semantic fluency task, verbal working memory (Operation Span), visuo-spatial working memory test (Symmetry Span), and two tests on vocabulary knowledge (Vocabulary Level Test [VLT] and Lexical Test for Advanced Learners of English [LexTALE]).

Results: Comparative analysis was conducted between speech perception data of L2 listeners and data from native English speakers, collected in a previous study by our research team (Nagaraj et al., 2021). The perception scores were fitted with Generalized Linear Mixed Model. The findings indicated that the L2 listeners performed significantly poorer than the L1 listeners did in both audio-only (A) and audio-visual (AV) conditions, across both types of sentences. The L2 listeners showed a substantial improvement in the AV condition, particularly evident for AzBio sentences, whereas the visual benefit was notably diminished for QuickSIN sentences. Correlational analysis and Linear Mixed-effects model

were carried out to examine the role of WM abilities and vocabulary proficiency in L2 perception of interrupted speech. The results revealed that VLT that indexes the L2 listeners' vocabulary size was a significant factor in the perception of interrupted speech. Further analysis of the visual benefit (AV score minus A scores) using Linear Mixed-effects Model revealed that sentence type, VLT, and WM all emerged as significant factors in predicting the visual benefit of speech perception.

Conclusions: As expected, interrupted speech had a more adverse impact on non-native listeners compared to native listeners. The addition of visual cues significantly improved the perception of interrupted-speech. However, the magnitude of this visual benefit was substantially reduced for the sentences with limited contextual cues. The vocabulary size of L2 listeners was a crucial factor in the perceptual restoration and audiovisual integration during the perception of interrupted speech. Additionally, WMC capacity played an important role in audiovisual integration, particularly for sentences with limited semantic context.

AUDITORY PROCESSING / LISTENING EFFORT

Category: Auditory Processing/Listening Effort

Poster #: 243

The Effects of Age and Hearing Loss on Listening Effort in a Dichotic Digit Task

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Objectives: Recognizing speech in the presence of a competing talker is thought to require substantial mental effort. Collecting objective measures of listening effort on large numbers of patients is currently impractical in a clinical setting. Here, the existing clinical dichotic digits task was modified to depend on both selective attention and memory to provide a clinically feasible test of listening effort. We hypothesized that listening effort on this task would correlate with age and hearing loss. Understanding the extent to which age and hearing loss impact listening effort will allow hearing healthcare providers to better understand which patients experiencing listening difficulties may benefit from auditory rehabilitation strategies that aim to reduce listening effort.

Design: The behavioral dichotic digit identification task, where there is no within-ear masking and only across-ear masking, consisted of 4 conditions: Intelligibility (identification of an single digit presented at the designated target ear), Selective Attention (identification while ignoring a contralaterally presented masking digit), Memory (identification of a sequence of 4 digits), and Dual Task (identification of a sequence of 4 digits while ignoring a contralaterally presented sequence of masking digits). Performance, as well as response time and subjective ratings of effort and fatigue, was measured for each condition. By computing the interaction between the conditions, the effects of age and hearing loss on listening effort can be quantified independently from effects on intelligibility, selective attention, and memory.

Participants (N = 14; age 21 to 84 years old; all-frequency pure tone average -1 to 67 dB HL) were tested in an audiometric booth in the clinic.

Results: Performance in the intelligibility condition was nearly perfect for all subjects. Performance in the selective attention (M = 93 percent correct), memory (M = 86 percent correct), and dual task (M = 66 percent correct) conditions were negatively affected by age and hearing loss. As expected, age and hearing loss were highly correlated making differentiating between the two difficult. Performance in the dual task condition, along with response time and perceived effort and fatigue, can be well predicted from the intelligibility, selective attention, and memory conditions without the need for an interaction term.

Conclusions: An across-ear informational masker degrades performance, slows response time and increases subjective ratings of effort and fatigue. This degradation depends on the age and amount of hearing loss of participants. The lack of a substantial interaction between intelligibility, selective attention, and memory suggests that the across-ear masker does not increase listening effort in these subjects. The ability to collect an objective measure of listening effort in a clinical environment will allow for the testing of much larger numbers of participants in the future, thus allowing for better identifying subtle effects of age and hearing loss on listening demands. The views expressed in this abstract are those of the authors and do not reflect the official policy of the Department of Army/Navy/Air Force, Department of Defense, or U.S. Government.