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PODIUM ABSTRACTS

PODIUM SESSION I: HEARING AIDS AND AUDITORY IMPLANTS

Real-World Benefits of Cochlear Implants in Individuals with Single-Sided Deafness
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Objectives: Most cochlear implant (CI) research focuses on determining the effect of intervention on laboratory outcomes, such as speech perception. The overall goal of this study was to demonstrate the impact of CI over time for individuals with single-sided deafness on hearing-related functions and disability in the user's natural environments. We hypothesized that hearing loss-related psychosocial well-being (e.g., depression, anxiety, social isolation) would be improved following CI.

Design: Eleven subjects with single-sided deafness (SSD) were asked to utilize our smartphone-based ecological momentary assessment (EMA) application to answer up to 7 surveys a day for 1 week preoperatively, at 3-, 6-, and 12 months postoperatively to capture their real-time listening experiences in their natural environments. Subjects were also tested in a laboratory setting at each over time interval on CNC words, AzBio Sentences in noise, and localization. Retrospective questionnaires were also administered to assess satisfaction with the CI and perceived handicap because of the hearing loss.

Results: Subjects completed over 1000 surveys over the 1-year time frame. Significant improvement was demonstrated in all areas of psychosocial well-being, including depression, anxiety, and social isolation. Subjects also reported significantly less effortful listening in backgrounds of noise, which was corroborated by laboratory testing in noise.

Conclusions: Consistent with much of the literature findings, the use of a CI for individuals with SSD demonstrated great benefit on laboratory measures. Using EMA methodology, we were better able to elevate our understanding of the benefits that the CI by assessing benefits in the users real-world. Our study demonstrated improved quality of life by reduced anxiety, depression, loneliness, and social isolation.

Stimulation Location Affects Cochlear Implant Users' Vocal Pitch and Timbre
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Objectives: Adults with bilateral cochlear implants (CIs) produce different vocal pitches (F0) when producing sustained vowels and singing "Happy Birthday" depending on whether they are using their left or right CI. Electrode insertion depth variability across ears may be one cause of this difference. The goal of this study was to investigate the role of insertion depth on CI users' vocal productions.

Design: Eleven bilateral CI users participated in this study. In order to simulate differences in insertion depth, two eighteen electrode maps were created, one shifted apically by deactivating the four most basal

electrodes and one shifted basally by deactivating the four most apical electrodes. Data were collected for two vocal tasks that previous data indicated yielded different pitches when CI users listened to their own voice with their left versus right CI: producing a sustained vowel and singing "Happy Birthday."

Results: The results indicated that many participants significantly shifted the pitch of their voice in response to different simulated insertion depths, but the shift was not in a consistent direction. Spectrums of the vocal productions indicated that the distribution of energy across the spectrum often differed across simulated insertion depths, suggesting that changes in simulated insertion depth resulted in changes in timbre.

Conclusions: The results of this study suggest insertion depth differences may lead to differences in produced vocal pitch, but the effect may be mediated through changes in timbre.

Listening Effort in CI Users Impairs Perception of Later Utterances
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Objectives: People with hearing difficulty often need to fill in a missing word that was masked or misperceived. Contextual cues help accomplish this speech repair process, but at the cost of increased effort that can go unnoticed on an audiogram and unnoticed in conversation. Previous work shows that this effort extends forward in time a few seconds after a sentence is over, suggesting prolonged consideration as the sentence is mentally re-assembled. In clinics and in labs, speech perception is typically tested one utterance at a time, critically overlooking how this problem will affect perception of a sentence that immediately follows the first. The current study directly studies this phenomenon using stimuli that were designed to force mental repair of a word in a sentence that is followed immediately by probe stimuli (digits) that could be missed if the listener is still focused on repairing the first sentence.

Design: Sentence stimuli were either fully intact or contained one word masked out by noise but recoverable by later context (forcing mental repair). Sentences were followed by 2 seconds of silence, 3 digits that were ignored, or 3 digits that were repeated along with the sentence. Digits were used as a listening probe that did not semantically interact with the effort of processing the sentence. Effort was tracked via pupillometry that was time locked to the moment of misperceptions. Participants were 20 listeners with normal hearing and 22 cochlear implant listeners.

Results: When sentences required mental repair, CI listeners made more errors elsewhere in the sentence, suggesting effort of repairing one word spreads to jeopardize later words. Repairing a missing word also led to more mistakes on subsequent digits for CI listeners, but not for NH listeners, suggesting lingering effort in the CI group that was resolved more quickly for NH listeners. Across the conditions increasing by difficulty (silence, digits ignored, digits repeated), pupil responses increased for NH and decreased for the CI group, suggesting conservation of effort. Pupil dilation reliably increased at the exact moment when a word needed to be repaired by context. For CI listeners, this increased effort response was strongest when they had silent opportunity after the sentence, but was partially suppressed (both in magnitude and in time) when there were digits spoken after the sentence.

Conclusions: The duration of listening effort is potentially even more important than the amount of effort. Listening effort emerges from mental repair of missing words in the attempt to assemble coherence of a sentence. This type of effort cannot be measured in simpler stimuli like single words or digit triplets that

lack opportunity for incoherence or construction. Effort persists over time to jeopardize perception of a following utterance, which helps to explain how a single mistake can de-rail an entire conversational sequence. The current study provides a paradigm for revealing this pattern behaviorally with complementary physiological evidence of dynamic changes in listening effort.

Preference Evaluation for Listening Intent based Hearing Aid Adjustments

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Objectives: Automatic Environment Classification (AEC) is essentially a part of all commercially available hearing aids. AEC algorithms, identify the acoustic environment of the user and adapt the hearing aids response to optimize listening in the identified acoustic environment. Despite these automatic optimizations, some listening environments continue to be challenging to the hearing aid wearer. One potential reason is that automatic systems are based on assumptions of what is important to the wearer in each acoustic scenario. These automatic algorithms don't account for the fact that an individual's listening 'intention' is variable in each listening situation and depends on several acoustic and non-acoustic factors. In this study we evaluated user preference for two hearing aids setting one programmed based on the analysis of the acoustic environment and assumed intent and another where the intent was explicitly elicited. Our hypothesis was that we will see a greater preference for hearing aid settings that were based on the user's explicit intent in each environment.

Design: Fourteen hearing impaired individuals evaluated their overall preference for two hearing aid settings-1. Generic adjustments made by an audiologist based on the assumption of a person's intent in each acoustic scenario (Assumed Intent) 2. Adjustments made by the same audiologist based on hearing aid wearer's elicited intent in each acoustic scenario (Explicit Intent). Hearing aid gain, compression, expansion, noise reduction and microphone directionality were adjusted. Only two listening intents were explored in this study ‚Äì listening comfort and communication. Hearing aid adjustments for each intention in pre-defined acoustic categories were programmed into a custom iPhone application and retrieved based on pre-defined logic. When the individuals' indicated intent was different than the assumed intent for the identified acoustic scene, participants evaluated the two settings in real time via pairwise comparisons using the above mentioned iPhone application. Comparisons were made in individuals real world environments as well as in simulated lab environments.

Results: The results of the study indicate that, participants significantly preferred the Explicit Intent based adjustments over the Assumed Intent adjustments in their real-world listening situations. Even in the simulated lab environments, participants showed preference for explicit intent-based adjustments over assumed intent adjustments. However, this difference in preference was not statistically significant. This could be due to the small number of comparisons conducted in the lab due to limited time availability.

Conclusions: Overall, the findings confirm the influence a hearing aid wearer's listening intention has on their preference of hearing aid settings. The preference for explicit intent suggests that acoustics of an environment alone isn't enough to provide optimal adjustments. While additional research is required including other listening intents such as annoyance and other non-acoustic factors such as cognition, these findings have implications for manufacturer's and for hearing health care professionals to find ways of incorporating a user's intent in fine tuning applications and adjustments respectively.

Low-Gain Hearing Aids for Listening-in-Noise Difficulties in "Normal Hearing" Individuals

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Objectives: Approximately one in ten adults who present to the clinic reporting difficulty understanding speech in noise have normal audiometric thresholds. National Acoustic Laboratories (NAL) research revealed that this creates a dilemma for the clinicians attending them as there is no standardised clinical approach available to address their hearing issues. Both the clients and clinicians often report feeling frustrated, confused and disempowered. This study aimed to evaluate the value of low-gain hearing aids as a potential intervention for the individuals with normal audiograms who present abnormal speech-in-noise hearing difficulties. We hypothesized that the directionality provided by low-gain hearing aids would provide an acoustic advantage, which would improve their hearing experience in both simulated and real-world noisy venues.

Design: This project followed a randomised controlled trial with (i) 14 control participants fitted with a Phonak Marvel Audeo M50 with an amplification gain close to 0 dB, and (ii) 13 experimental participants fitted with hearing aids of the same model but with an amplification gain close to +8 dB. Participants had clinically normal hearing thresholds and reported speech-in-noise hearing difficulties. Testing consisted of questionnaires, real-world assessment via ecological momentary assessment tools, and laboratory testing in an anechoic chamber including ECO-SiN (a speech-in-noise intelligibility test that uses ecologically valid speech stimuli and background noise) and listening effort (a behavioural dual-task based on reaction time and self-reported measures based on a questionnaire).

Results: At group level, results revealed that the acoustic advantage provided by hearing aids leads to a moderate improvement in the hearing experience of users. Results also showed a large inter-subject variability, with some participants experiencing a large benefit while others did not. For example, one participant reported "I used the hearing aids in a very noisy bar and it was absolutely brilliant! Do I really have to return them at the end of the study? Where can I buy one? It made the whole experience so much more pleasurable and my friends who were having similar issues all want one too!". Results from a questionnaire showed that participants' self-perceived hearing difficulties improved [on a scale from 0 (Extreme difficulties) to 10 (No difficulties)] from a mean score of 5.1 without hearing aids to 6.4 with hearing aids. Participants satisfaction with hearing aids was 3.9, on a scale from 0 (Not satisfied at all) to 6 (Fully satisfied).

Conclusions: Together, the results demonstrate that low-gain hearing aids lead to a moderate improvement in the hearing experience of users. This outcome will assist audiologists to provide more informed recommendations to clients with normal audiograms and speech-in-noise hearing difficulties, as well as manage the expectations of their patients. These results also open new research opportunities, including the evaluation of hearables as an alternative intervention for these individuals.

Electroacoustic, Fitting, and Sound Quality of Over-the-Counter Amplification

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Objectives: Over-the-counter hearing aids (OTC-HAs) were authorized by the U.S. Food and Drug Administration (FDA) in the Reauthorization Act of 2017 in response to calls for increased affordability and accessibility to hearing healthcare. The FDA recently published proposed safety and efficacy regulations for these OTC-HAs on 10/20/2021. The reauthorization act and regulations provide a new delivery model for individuals to purchase amplification directly without assistance from healthcare professions. This research addressed the following research questions: 1) do current OTC amplification devices meet the proposed safety and efficacy guidelines published by the FDA?, 2) can these same OTC amplification devices provide appropriate amplification for different hearing losses?, and 3) how do these OTC amplification devices compare to traditional hearing aids for speech perception and sound quality?. We hypothesized that OTC amplification devices would often not meet the proposed guidelines, that they would not provide as appropriate amplification as traditional hearing aids, and that they would have poorer speech perception and sound quality than traditional hearing aids.

Design: Six OTC devices and three traditional hearing aids were tested electroacoustically according to the American National Standards Institute's standards on hearing aids. The electroacoustic results of the OTC devices were compared to the proposed guidelines from the FDA. Each device was then programmed to match prescriptive targets for hearing aid output as closely as possible for three hearing losses using real-ear verification in an acoustic manikin. The deviations from targets for the OTC devices were compared to those of the traditional hearing aids. Finally. adults with normal hearing and simulated hearing losses (flat moderate, mild to moderate, mild to severe) completed speech perception testing with and rated the sound quality of all nine devices. To allow efficient testing with multiple devices, recordings materials were made with each device in an acoustic manikin. Sound quality ratings were completed for four sound scenarios (music, traffic, party, nature) using the MUlti Stimulus test with Hidden Reference and Anchor test. Participants completed speech recognition testing using the QuickSIN.

Results: More than half of the OTC amplification devices did not meet the three FDA proposed guidelines for maximum output level, total harmonic distortion, equivalent input noise, and frequency range. Traditional hearing aids could be programmed to match prescribed output targets better than OTC devices. There was large variability, however, across the OTC devices with some matching targets well. All devices generally increased sound quality and speech perception for participants compared to unaided hearing loss. Some individual hearing aids and OTCs had better sound quality than other devices depending on the listening situation and degree of hearing loss. Only a couple of the OTCs resulted in poorer speech perception than all the other devices.

Conclusions: Some OTC devices meet the proposed guidelines for safety and efficacy and can provide appropriate amplification for hearing loss and speech perception and sound quality. Unfortunately, other devices do none of these things. It is important that consumers and hearing healthcare professionals know how to identify the quality OTC devices that can treat mild-moderate hearing loss appropriately.

PODIUM SESSION II: TINNITUS, TRAUMA, AND THERAPEUTICS

Evaluation of Residual Inhibition Therapy for Sustained Suppression of Tinnitus

New Investigator Presentation

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Objectives: Tinnitus acoustic therapy is defined as any use of sound where the intent is to alter the tinnitus perception and/or the reactions to tinnitus in a clinically beneficial way. The parameters of sound that cause beneficial effects, however, are currently only theorized with limited data supporting their effectiveness. Our pilot study investigated the effects of a therapeutic acoustic stimulus that was individually customized to maximize residual inhibition (RI) of tinnitus (i.e., the temporary suppression or elimination of tinnitus that is usually observed following appropriate auditory stimulation) and extend its duration to produce a sustained suppression of the tinnitus signal. The maximization of RI may also provide a feeling of control to patients over their tinnitus, and this may have a synergistic effect in reducing the psychological and emotional distress associated with tinnitus. The combination of these benefits may reduce tinnitus and improve quality of life in both the short and long term.

Design: The study enrolled 15 participants with chronic tinnitus. Each participant completed a psychoacoustic test battery (e.g., tinnitus loudness and pitch matching) to determine appropriate RI stimulus and complete outcome measures. The primary outcome measure used to track change in tinnitus perception was the Tinnitus Functional Index (TFI). Sound delivery of RI stimulus was accomplished using an ear-level device modified to incorporate the RI stimulus via Bluetooth. Appropriate amplification was given to those with hearing loss to be verified by real-ear measures. All participants were instructed to listen to the RI stimulus for all waking hours for a 2-month treatment period. Most participants returned to repeat outcome measures and psychoacoustic testing 1-2 weeks post baseline. Participants returned 2 months after baseline to turn off residual inhibition stimulus and 1 month after (3 months post baseline) to assess any lasting effects of treatment protocol.

Results: Repeated measures Analyses of Variance (ANOVA) were run on the two main outcomes (TFI score and Loudness matching) across all 4 visits. The repeated measures ANOVA on loudness match across the 4 study visits did not show a significant change ($p=0.480$). However, the repeated measures ANOVA on TFI score showed a significant change across visits ($p<0.0001$).

Conclusions: The main objective of this pilot study was to demonstrate the feasibility and acceptability of RI as a sound therapy for tinnitus, specifically through the daily use of hearing aids. The overall participant scores of the TFI demonstrated a positive change in tinnitus reactions over the course of the treatment period, indicating that RI could be a potential sound therapy option for chronic tinnitus patients. The use of hearing aids allowed for an immersive therapy experience that could potentially sustain the effect of residual inhibition on tinnitus perception. However, a larger-scale study is needed to determine the validity of using RI as a clinical therapy option and to ascertain any effects on both perception and reaction to tinnitus.

COVID-19, Hearing Loss and Tinnitus: Causality or Spurious Conjunction?

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Objectives: Systematic reviews and anecdotal reports suggest a link between COVID-19 and audiovestibular damage. However, most studies have relied on self-report, and lack baseline data and/or a control group. As a result, it is difficult to differentiate whether symptoms reported are more closely associated with COVID-19 infection, or with issues such as anxiety or reporting bias. The objective of this study was to make this differentiation by comparing data on auditory and non-auditory symptoms reported by individuals prior to, and during the pandemic. This was achieved by comparing data obtained in March 2019 with follow-up data collected in August/September 2021. Participants were asked about the onset, duration and change in specific symptoms, three of which have a known association with COVID-19 illness (persistent fatigue, loss of smell, problems with memory and concentration), two have an indeterminate association (hearing loss, tinnitus), and one has no known association with COVID-19 illness (toothache). The rationale is that if hearing difficulties and/or tinnitus are directly associated with COVID-19, the pattern of onset, duration and change would be similar to that seen for symptoms with a known association with COVID-19. Conversely, if hearing loss and/or tinnitus are indirectly associated with COVID-19, reflecting psychosocial factors and/or recall bias, then the pattern of onset, duration and change would be more similar to that seen for symptoms not associated with COVID-19.

Design: The baseline survey was completed by 10,401 individuals in March 2019. These individuals were re-contacted in August 2021 to complete the follow-up survey. Follow-up questions addressed COVID-19 illness, onset, duration and change in the six symptoms above, ratings of hearing and tinnitus, and use of hearing assistive technology. No reference was made to a specific interest in audio-vestibular symptoms.

Results: Complete surveys were received from 6881 individuals (mean age = 54.5 yr., 95.4% white, 52.8% female). Six percent reported COVID-19 confirmed by a positive test (COVID+), 11% thought they probably had COVID-19 (COVID-P), and 83% said no to having COVID-19 (COVID-0). Over 90% had received 2 doses of vaccine. About 20% of participants reported new hearing difficulties and/or tinnitus in the follow-up survey, with reports significantly greater in COVID+ and COVID-P individuals thanCOVID-0 individuals. However, a direct association cannot be assumed for several reasons (i) just 10% of participants reported the onset of hearing difficulty and/or tinnitus to coincide with being ill with COVID-19, (ii) >40% said that their hearing difficulty/tinnitus had begun before the pandemic despite having not reported hearing difficulty and/or tinnitus at baseline, (iii) reported hearing difficulty or tinnitus was more common among COVID-P participants than COVID-0 participants, but not COVID+ participants and COVID-0 participants, and (d) there were significantly more reports of toothache (currently no known association with COVID-19) among COVID-P individuals than among either of the other two groups.

Conclusions: COVID-19 could result in hearing difficulties and/or tinnitus in as many as 20% of the infected population, however the data must be interpreted with caution as they are confounded by inconsistent reporting and/or recall of these symptoms.

Auditory Nerve Fibers - Who's Most Vulnerable to Noise and Aging?

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Objectives: Sound coding by the cochlea must accurately represent parameters of complex sounds in the frequency, level and time domains, and must do so by extracting these details in non-ideal coding environments; for example, when signals are degraded by noise or other distortions. These enormous demands on the neural circuitry are supported through activation of auditory nerve fibers with different characteristics of sound-driven activity, traditionally categorized by their spontaneous rates (SR) of firing. Our previous and ongoing work in animal models of noise- and aging-related hearing loss hypothesizes initial vulnerability of low-SR fibers. Work described here is part of a larger study that aims to clarify, by SR subtype, which neurons are most vulnerable to insult, which recover spontaneously or can be treated to re-establish functional connections with inner hair cells, and which functional metrics best reveal neural status. We undertake these studies in gerbil, an animal with a range of hearing sensitivity significantly overlapping human and with well-characterized differences in fiber SR distributions along the cochlear epithelium.

Design: Cochlear physiologic and histologic consequences of noise exposure and aging were assessed. For the noise exposure series, young animals (14 wk, n=88) were exposed (2.8-5.6 kHz, 100 or 103 dB SPL, 2 hr) and held, with unexposed controls, for varying post-exposure times (24h-10 wk) before functional assessments and retrieval of cochlear tissues. For the aging series (n=82), animals were held without intentional exposure from 6 to 144 wks. In all groups, cochlear function was assessed by distortion product otoacoustic emissions and by round-window recordings of auditory nerve compound action potentials, spontaneous activity and peri-stimulus time responses (PSTR) from 2-45 kHz. Immunostained cochlear whole mounts and frozen sections were studied to quantify hair cells, neurons and the synapses that connect them, and to characterize surviving fibers by SR subtype.

Results: Noise exposures produced 24-hr threshold elevations up to 50 dB, followed by near-total recovery. There was no hair cell loss. Neural response amplitudes remained reduced from pre-exposure values at 10 weeks. Synapse loss outpaced neural amplitude declines at extended post-noise times. Reductions in neural activity at acute vs. extended post-exposure times suggested temporary involvement of high-SR neurons but persistent dysfunction of low-SR ANFs. Exaggerated and persistent declines in spontaneous activity and stimulated PSTRs for higher-dose noise suggests involvement of medium- and high-SR fibers as well. In aging ears, threshold elevations and suprathreshold amplitude declines were mild over the age range monitored. Hair cell losses were small in oldest animals and restricted to the extreme cochlear apex and base. IHC synapse losses progressed gradually with age across frequency and were modest in degree in oldest ears. Round window recorded spontaneous activity and sound-driven PSTRs suggested initial low-SR, then mixed fiber loss by SR subtype as animals aged.

Conclusions: Declines in neural activity suggest noise-dose and age-sensitive involvement by SR subtype. Results will inform our understanding of the declines in function underlying injury, informing efforts toward improved clinical diagnosis and treatment.Work supported by grants from the NIH/NIDCD and the Office of Naval Research.

Verapamil: Effects on Hearing and Inhibition of Acoustic Startle

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Objectives: Hearing loss affects approximately 48 million Americans. Increased spontaneous neuronal activity often occurs in auditory pathways following hearing loss. One of the leading hypotheses is that after hearing loss the reduction in the afferent input to the ear leads to central hyperactivity to compensate for the decrease of input (Schrode et al., 2018). Voltage-gated calcium channels regulate neuronal activity. Therefore, we examined the effect of the L-type calcium channel blocker, verapamil, in normal hearing and noise-exposed rats. The response of the auditory nerve and the inferior colliculus during auditory brainstem response (ABR; wave I and wave V respectively) was tested.

Design: Twenty-five male Sprague-Dawley rats were divided into four groups (n = 5 - 7/group) and given either verapamil (30 mg/kg) or saline solution intraperitoneally. The treatment groups were: a) no noise exposure plus verapamil (n=5), b) no noise exposure plus saline (n=6), c) noise exposure plus verapamil (n=7), and d) noise exposure plus saline (n=7). The noise groups were unilaterally exposed to a 16 kHz, 106 dB SPL tone for one hour, while no noise control groups were maintained in ambient noise conditions for an equal amount of time. For ABR analysis both amplitudes (wave I and V) and thresholds were evaluated. The assessment was performed at two different frequencies (12 kHz and 20 kHz) and time points (one and five days after treatment).

Results: Verapamil administration did not have any negative effect on the hearing threshold. In fact, when the noise groups had a temporary threshold shift (TTS), verapamil decreased the recovery time. The administration of verapamil had an effect on the amplitudes of both ABR waves assessed. In no noise conditions, administration of verapamil (n=5) caused a significant increase in wave V amplitude compared to the saline group (n=6) one day after treatment (8.4% at 12 kHz, $p<0.05$). The wave V/I ratio in the no noise saline group at 12 kHz one day after treatment was 0.393 and in the no noise verapamil group at 12 kHz one day after treatment was 0.667 ($p<0.12$). The wave V/I ratio in the no noise saline group at 20 kHz one day after treatment was 0.523 and in the no noise verapamil group at 20 kHz one day after treatment was 0.667 ($p<0.13$). The wave V/I ratio for the verapamil no noise group was significantly increased (95% at 12 kHz, $p<0.02$) five days after verapamil treatment.

Conclusions: Our results demonstrate that verapamil may increase gain in the inferior colliculus. Future studies should focus on further understanding the relationship among changes in neuronal activity, voltage-gated calcium channels, and susceptibility to noise-induced hearing loss and tinnitus.

Neurotrophin OTO-413 for Hearing Loss: Phase 1/2 Clinical Study

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Objectives: Cochlear synaptopathy plays a role in hearing loss after noise trauma and in aging. Treatment with brain derived neurotrophic factor (BDNF) repairs synaptic processes and restores hearing function in animal models. OTO-413, a sustained-exposure formulation of BDNF for intratympanic administration, is under evaluation for the treatment of hearing loss. The objective of this initial clinical study with OTO-

413 is to evaluate the safety and exploratory efficacy of OTO-413 for treatment of individuals with hearing loss.

Design: Randomized, double-blind, placebo-controlled Phase 1/2 study. Men and women participants aged 21-64 years with self-reported difficulty hearing in noise were enrolled between December 2019 and August 2020. Their tone thresholds ranged from normal levels to moderately severe hearing loss (pure tone average, PTA ≤ 70 dB at 1, 2, 4 kHz). They all had elevated Digits-in-Noise (DIN, 4 kHz low pass noise) test scores in the study ear (speech reception threshold, SRT > -12.5 dB). Four ascending dose-cohorts of at least 8 participants each received a single intratympanic injection of OTO-413 or placebo. Safety and hearing function were monitored over a 12-week follow-up. Hearing assessments included DIN, Words-in-Noise (WIN), and American English Matrix test. English was required to be participants' first/primary language, and all had scores ≥24 on the Mini-Mental State Examination to ensure performance on the speech-in-noise tests was not impacted by English fluency or cognitive impairment, respectively.

Results: Safety was evaluated in all dose cohorts (n=29, OTO-413; n =10 Placebo) and exploratory efficacy was assessed for the highest dose (Cohort 4: n=9, OTO-413 [0.30 mg]; n=8 Placebo pooled from Cohorts 2, 3, and 4). OTO-413 was well-tolerated across all dose cohorts with similar frequency of adverse events compared to placebo. There were no serious adverse events. A clinically meaningful improvement was defined as a minimum change of -3 dB SRT (DIN) or -2 dB SRT (WIN, American English Matrix test). Six of 9 (67%) OTO-413 participants treated with the highest dose of OTO-413 (0.30 mg) showed a clinically meaningful improvement on at least one of the three speech-in-noise tests at both Day 57 and Day 85 compared with 0/8 (0%) for Placebo. Four of 9 (44%) OTO-413 treated participants experienced a clinically meaningful improvement on the Matrix test at both Days 57 and 85 compared to 0 of 7 (0%) subjects in the Placebo group at any single timepoint.

Conclusions: OTO-413 was well-tolerated after a single intratympanic injection across all dose cohorts. In the exploratory efficacy cohort, more OTO-413 participants demonstrated clinically meaningful improvements on at least one speech-in-noise test at both Days 57 and 85 compared with participants receiving the placebo. These initial observations demonstrate proof of concept of OTO-413 for the treatment of hearing loss and support further clinical development. Additional evaluation of the 0.30 mg OTO-413 dose level (n=30) is underway.

Prevalence of Noise-Induced Hearing Loss in the U.S.A.

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Objectives: The method of Moore (2020) for diagnosing Military-Noise-Induced Hearing Loss (M-NIHL) was applied to the National Health and Nutrition Examination Survey (NHANES) 2011-2012 dataset to determine the prevalence of NIHL among a representative cross-section of Americans between the ages of 20 and 69 years.

Design: The NHANES 2011-2012 dataset includes audiograms from adults ranging in age from 20-69 years. The NHANES survey is designed to sample a representative cross-section of Americans in terms of gender, race, and ethnicity. Noise-exposure survey responses were available for queries about prior military service, number of firearm rounds fired, duration of exposure to loud noise at work, and off-

work noise exposures. Complete audiometric and survey data from 1,887 males and 1,773 females, a total of 3,660 adults, formed the dataset used in the application of the M-NIHL method.

Results: Although only 12.8% of males and 1.3% of females in NHANES 2011-2012 reported prior active-duty military service, 51.5% of males and 19.7% of females reported prior use of firearms and over 25% of males reported firing 100-10,000 rounds, often without hearing protection. For occupational exposures, 47.1% of males and 21.0% of females reported loud or very loud exposures. For 10.1% of females and 26.8% of males, the duration of such exposures was 5 or more years. Finally, 7.0% of females and 17.2% of males reported off-work exposures to loud noise or music for 10 or more hours per week. Affirmative responses to any of the queries about noise exposure were considered as positive noise-exposure histories. About 38% of females and 71% of males had positive noise-exposure histories.The method of Moore has three required criteria, labeled R0, R1, and R2a/R2b, that must be met for a positive diagnosis of NIHL. The first criterion, R0 is a positive noise-exposure history and, as noted above, 38% of females and 71% of males met R0. The R1 criterion requires greater hearing loss at high than at low frequencies. R1 was met by 69.5% of males and 36.4% of females who met R0. Criterion R2a, which is basically an audiometric-notch criterion, was met by 61.6% of the males and 51.1% of the females who met the R0 and R1 criteria. Finally, for those who met R0 and R1 criteria, but not the R2a criterion, an alternative criterion based on the severity of the high-frequency hearing loss, R2b, is considered. In this case, 57.3% of the males and 55.4% of the females who met R0 and R1 but not R2a, met the R2b criterion. All told, based on the application of the M-NIHL method, 58.1% of US males and 28.5% of US females were estimated to have NIHL. Prevalence increased with increasing age from 20-69 years for both genders. Further evaluation of each criterion in the M-NIHL method will be presented.

Conclusions: American adults have many noisy experiences, including several unrelated to work, that can result in 29-58% of Americans experiencing NIHL.

PODIUM SESSION III: HEARING AND BALANCE HEALTHCARE DELIVERY

Knowledge, Attitudes, and Beliefs about Hearing Loss and Hearing Health Care among Hispanic/LatinX Adults: Focus Group Results

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Objectives: The purpose of our study was to inform the development of a culturally and linguistically appropriate self-management program for Hispanic/LatinX adults with hearing loss. A first step in developing these materials was to better understand the learning needs by assessing hearing health care knowledge, attitudes, and behaviors. Through a series of focus groups with members of the target audience, we explored knowledge about hearing loss and hearing loss interventions, cultural facilitators and barriers to hearing health care utilization, and preferences for hearing health education and information delivery. We also received feedback on prototype patient education materials designed to increase self-efficacy for managing hearing loss in daily life.

Design: Our work was guided by a practical framework of cultural competence interventions for addressing disparities in health and health care, centered on structural, clinical, and organizational barriers to care. We utilized a hybrid individualistic social psychology and social constructionist approach to build programmatic theory related to our primary research objective. Focus group goals

were to generate a combination of personal opinions and collective experiences from participants with an a priori plan to analyze data using combined content analysis/grounded theory methods. Purposive sampling was used to select participants who were Spanish-speaking, identified as Hispanic/LatinX, and who had normal hearing or self-reported hearing difficulties. Focus groups were conducted using Microsoft Teams, and each group was audio and video recorded for later offline transcription, translation, and analysis. A constant comparison approach was used to systematically organize focus group data into a structured format for interpretation. Transcripts were coded independently by 3 investigators, and emergent themes were derived and interpreted from the coded data.

Results: Major and minor themes tied to the framework for culturally-competent interventions included those related to sociocultural barriers to care. Structural barriers, including inconsistent access to quality care, lack of culturally and linguistically appropriate patient education materials, appointment wait times and intake processes, and referrals to specialty care, were most frequently experienced by our focus group participants or their family members. Clinical barriers most frequently cited were a lack of culturally and linguistically congruent healthcare providers and lack of language access during healthcare visits. Other major themes included hearing loss lived experiences, family and familism, and hearing-related patient education needs and preferences.

Conclusions: Emergent themes were uncovered that provided insight regarding the knowledge, attitudes, and beliefs about hearing loss and hearing health care, including hearing-related learning needs, of the Hispanic/LatinX adults in our sample. We integrated the results from our focus groups into a Spanish-language hearing loss self-management program that is currently being tested in a randomized controlled trial (RCT; clinicaltrials.gov ID NCT04534387).

Consumer Opinions of Direct-to-Consumer Models of Hearing Healthcare

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Objectives: The Over-the-Counter Hearing Aid Act (2017) and the recent rule making by the Food and Drug Administration is ushering in a complete paradigm shift in hearing healthcare delivery. Online sources of hearing aids or similar devices are already available and growing, and 22% of non-hearing aid users report that they are likely to purchase their first hearing aid via a direct-to-consumer (DTC) option. Additionally, older adults who currently use hearing aids, are willing to learn about DTC pathways even when they lack awareness of digital models of hearing healthcare. These findings suggest that there is a segment of adults with hearing loss who will choose to pursue hearing aid treatment through these non-traditional pathways. However, little is known about these individuals and the factors that influence their choice from a consumer perspective. Understanding consumer behaviors and attitudes related to health seeking and decision making is an integral component of evaluating the efficacy of direct-to-consumer pathways of hearing healthcare. Thus, the purpose of the present study was to determine attitudes about direct-to-consumer pathways of hearing healthcare and the factors that drive one to pursue hearing aids through these novel pathways.

Design: Semi-structured interviews were conducted with 11 non-hearing aid users between the ages of 50 and 79 years old (5 men, 6 women). Using an interview guide, participants were asked to discuss their familiarity with hearing aids, the process for obtaining them, and their thoughts about the need for a healthcare professional when purchasing hearing aids. All participants were then provided with an overview of the two potential pathways for obtaining a hearing aid (provider driven or DTC) and were

asked to discuss which option they felt would be the most appropriate for them. Interviews were recorded and transcribed via Zoom. Thematic coding and analysis were completed independently by two reviewers. Natural language processing techniques were also applied to extract, categorize, and organize common themes using machine learning.

Results: Preliminary results suggest that most participants were unsure of what DTC hearing aid options were currently available. However, they were aware of other DTC healthcare industries (i.e., Warby Parker) and the potential advantages and disadvantages of choosing these options over traditional, in-person services. Among those who have used other DTC healthcare platforms, their experience with these companies largely dictated their expectations of DTC hearing aids. Furthermore, given the infancy of DTC hearing healthcare, many participants reported that recommendations from their physician or friends would largely drive their decision to consider DTC hearing aids. However, many participants reported that their lack of experience with hearing aids would require the need for some form of professional service.

Conclusions: Most participants were aware of and could enumerate specific benefits of DTC healthcare, and would consider pursuing DTC hearing healthcare if it was recommended by a trusted source (i.e., physician or friend). However, many participants would still opt for having professional services to ensure efficacy of treatment.

Readiness of Low Income Hearing Help Seekers for Telehealth

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Objectives: Medicaid and Medicare eligible adults with hearing loss have twice as much difficulty using their hearing aids than their peers with higher incomes. Follow up appointments for new hearing aid wearers with low incomes are critical for positive outcomes and may be easier to attend via telehealth. Telehealth requires basic technological skills with mobile devices and/or computers. Further, a recent cross-sectional survey of direct-to-consumer hearing aids available for purchase online found that most offered devices which paired to smartphones and had telehealth follow up services for patients. Our objective was to assess the readiness of hearing help seekers with low incomes for telehealth.

Design: A cross-sectional survey was used to assess attitudinal and technological readiness for telehealth. The Mobile Device Proficiency Questionnaire, the Computer Proficiency Questionnaire, and the revised Readiness for Telehealth Survey were mailed to 106 patients who had obtained hearing aids through our community hearing aid bank during the last few years and had the ability to fill out a survey on their own.

Results: Forty-two patients (M = 13; F = 29) with a mean age of 63.4 y (SD = 23) returned surveys for a response rate of 42% (42/[106-7 return to sender]). Most took between 3 and 6 medications per day and had the following comorbidities: arthritis (50%; 21/42), hypertension (45%; 19/42), diabetes (43%; 18/42), ocular disorders/low vision (43%; 18/42), and hyperlipidemia (29%; 13/42). Patients reported living an average of 20 miles away from clinical services (M = 20.1; SD = 25) and 14% (6/42) did not have reliable transportation. Most respondents had access to email addresses (88%; 35/40), the Internet (80%; 33/41), smartphones (73%; 30/41), and tablets/computers (71%; 29/41), but were not confident at all or needed help in using their smartphones (56%; 22/39), computers (62%; 24/39), mouse (50% 19/38), and computer cameras (71%; 27/38). Further, many lacked basic skills with mobile devices and

computers. Only 39.5% (15/38) agreed with the statement "I would be willing to receive my hearing aid follow up appointments via telehealth." Two-fifths (40%; 16/40) agreed that that having follow up via telehealth would be more convenient than going to the clinic. Nearly two-thirds agreed with the statement, "I would miss interacting with the audiologists and student interns in person." Based on these results, we developed the Mobile Device Skill Overview for Aural Rehabilitation (MOD-SOAR) to screen technology skills required for telehealth. We will describe how the screening tool is used for providing individualized patient instruction. In addition, we developed an informational counseling module about telehealth to overcome attitudinal obstacles to this method of service delivery.

Conclusions: Although telehealth follow up appointments may be desired by some patients, directed training on skills for managing smartphones, tablets, and computers may be needed for success. In addition, these skills may be critical for using OTC hearing aids and interacting with the manufacturers of those devices. Limitations of this survey include self-selection bias, small sample size, patients from only one clinic, reliance on patients' self-reported rather than demonstrated abilities.

Preliminary Evaluation of Fall Risk Assessment Methods Using Ear-Wearable Devices
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Objectives: In recent years, motion sensors have been successfully embedded into commercially-available hearing aids for the purposes of tracking the wearer's daily physical activity and to automatically send notifications to caregivers when a fall event is detected. We postulate that these advanced ear-wearable devices may also be suitable for chronically monitoring the wearer's postural stability during structured and unstructured activities. For example, wearable motion sensor data, obtained during instrumented falls risk screening tasks, has previously been used to detect significant differences between fallers and non-fallers. Evidence also suggests that daily physical activity level and the experience of near falls are associated with incidence of future falls.The present authors will present preliminary findings regarding the technological feasibility of using hearing aids with embedded motion sensors to monitor a wearer's postural stability and assisting in the assessment of patients' future risk for falls.

Design: Study 1 compared clinician observation and artificial intelligence characterization of ear-level motion sensor data during administration of common functional balance screening tasks. Motion sensor data was recorded from participants (approximately n=70) while performing the Timed Up and Go (TUG) test, 4-stage Balance Test, and 30-Second Chair Stand Test. Automated assessments were compared to scores determined by clinician observation of video recordings taken during each participant trial.Study 2 evaluated the accuracy of an ear-level fall and near-fall classification system. Performance was measured using ear-level motion sensor data obtained during participants' (n=10) trials of simulated falls, near falls, and activities of daily living (ADLs).

Results: Preliminary analysis of the first 15 participants enrolled in Study 1 shows 62-100% agreement between manually scored and automatically characterized trials of the various structured functional falls risk screening tasks.Analysis of Study 2 indicates 83-92% accuracy for differentiating each of Falls, Near-Falls/Stumbles, and ADLs.

Conclusions: Ear-level motion sensor data and artificial intelligence can be used to assist in the interpretation of functional falls risk screening measures. Accurate detection of falls and near-fall events could contribute to the ongoing assessment of patients' future risk for falls.

Development of an Outcome Measure for Empowerment for Hearing Loss

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Objectives: Over the last few years, the concept of empowerment has emerged from studies of mhealth technologies, such as smartphone-connected hearing aids and multimedia educational resources for hearing aid users. However, there is currently no hearing-related measure of empowerment. Objectives of this research were to (i) conceptualise empowerment along the hearing patient journey, to then inform (ii) the development of an outcome measure of empowerment for adults with hearing loss.

Design: A semi-structured interview study was conducted in adult hearing aid users from Australia (n=10) and Sweden (n=8) who had worn hearing aids for between 6 to 36 months. A thematic template analysis was used, based on Zimmerman's theory of Empowerment. The results generated content for the development of an outcome measure of empowerment, based on best practice COSMIN guidelines. The relevance and clarity of the measure was evaluated through (i) cognitive interviews with a total of 16 adults with hearing loss (n=8 for both Australia and Denmark), and (ii) an expert panel of audiologists and researchers, initially in Sweden and then in Australia. The items will then be refined and their psychometric properties identified by applying modern psychometric analysis, namely Rasch analysis, and traditional analysis from more than 300 adults with hearing loss.

Results: The thematic dimensions that emerged from the interview study were knowledge, skills and strategies, participation, self-efficacy, and control of their hearing health care, hearing solutions and everyday lives. A pool of 38 items were initially generated across the five themes of empowerment. Following refinement as a result of 16 sets of cognitive interviews the final pool of items was 37. Relevance and clarity from the initial Swedish sample were 3.57 and 3.53 respectively. The Australian data are currently being collected. Over the next few months the psychometric analysis will identify whether or not the measure is uni-or multi-dimensional following removal of items with unfavourable properties, such as poor fit or redundancy. Reliability and validity will be established.

Conclusions: The first study conceptualized empowerment along the hearing patient journey aligned with five themes. There were no specific points along the journey where any dimension was uniquely relevant, and each dimension was a dynamic component at all stages. The resulting outcome measure, following psychometric analysis, will enable measurement of the concept of hearing-related empowerment prior to, and following hearing intervention, for example with hearing aids.

Implementation Science and the Uptake of a Post-Hearing-Screening Intervention

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Objectives: Principles of implementation science are used to translate effective clinical treatments from the research lab into the community. Whereas the concomitant effects of unaddressed hearing

impairment are well known, the majority of adults who fail a hearing screening take no action to evaluate or manage their hearing problems. We have developed an internet-based Decision Coaching Guide to increase the percentage of adults who visit an audiologist after failing a hearing screening. In addition to evaluating the efficacy of this treatment, we are determining whether the hearing screening setting influences the uptake of, and adherence to, the Decision Coaching Guide.

Design: We are evaluating the Reach and Adoption of the screening procedures and sites by considering the participation rate from each study arm, the distribution of subject characteristics who take up the Decision Coaching Guide, and how subject characteristics vary within and across the study arms, in those that take up the Decision Coaching Guide. We are evaluating the Implementation of each study arm by considering the types of stakeholders who we interact with in each study arm (e.g. office managers, physicians, nurses, medical assistants, activity directors, Health and Human Services officials, and digital advertising specialists) and the amount of time and money spent by the research team members in order to achieve stakeholder participation.

Results: Participants are adults between the ages of 65 and 85 years who answer "yes" to the question "Do you think you have a hearing loss right now?" For the Implementation Science part of this effectiveness study we will report the number of participants recruited from each study arm who take up and who complete the Decision Coaching Guide over a 10-month recruitment period. We will also determine how participant characteristics vary within and across the study arms, the stakeholder participation rates within and across the study arms, and the necessary activities and cost that would be required in order to achieve sustainable participation rates. We will be finished with data collection as of February 28, 2022.

Conclusions: The results of this study will be used to identify the barriers and facilitators to the implementation of hearing screenings, and follow-up services, in the community.

PODIUM SESSION IV: ELECTROPHYSIOLOGY AND DIAGNOSTICS

Simultaneous ABR and FFR Recording using a 'Click-Plus' Stimulus

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Objectives: In patients who cannot be reliably tested behaviorally, the gold standard for assessment of hearing thresholds is the auditory brainstem response (ABR). The ABR is widely utilized for its ease of recording, and the reliability of the response. While the ABR provides excellent information about hearing acuity, it is far less sensitive to suprathreshold deficits in neural encoding. In contrast, other electrophysiologic measures such as the frequency-following response (FFR) are far better than the ABR at observing suprathreshold encoding deficits. The ability to identify such deficits is crucial because they have been purported to influence language development and understanding speech in noise. Consistent with this view, the strength of the FFR has been proposed to be general measure of auditory neural integrity. Unfortunately, current clinical practice does not allow sufficient time to measure the ABR and FFR separately. Such time pressures could be alleviated, however, with use of a stimulus that allows for simultaneous recording of the ABR and FFR. As a preliminary step towards addressing this issue, our

current goal was to test a signal called a 'click plus' which can allow both responses to be recorded simultaneously.

Design: Here we recorded the ABR and FFR with different experimental conditions. First we recorded the ABR to a click stimulus with varying stimulus intensities. Second, we recorded the FFR using four different stimuli (100 Hz harmonic complex, 200 Hz harmonic complex, 100 Hz tone, and a synthetic /a/). Finally, we recorded the ABR and FFR simultaneously to a 'click plus' stimulus; this stimulus consisted of a click followed by 15 ms of silence, and then one of the stimuli used to elicit the FFR. The 'click plus' was recorded with each of the four stimuli used to elicit the FFR alone, using the same stimulus intensities as the ABR. Across all three conditions, recordings were made from young adults with normal hearing using clinical recording montages. Data were analyzed in two stages: First we compared the latency and amplitude of Waves I-V for the ABR-alone and the click plus conditions. Second, we compared the RMS amplitude of the FFR waveforms for the FFR-alone and click plus.

Results: While preliminary, our results indicate no differences in ABR waveforms elicited by a click stimulus presented either alone or as part of the 'click plus' stimulus. Latency-intensity functions for the ABR appeared to be similar for the click stimulus and for the click plus stimuli. Notably, the RMS amplitude of the FFR appeared to be slightly larger in the click plus condition than in the FFR-alone condition. No other differences were noted between FFRs recorded alone or as part of the click plus stimuli

Conclusions: Taken together, these results suggest that the ABR and FFR can be reliably recorded simultaneously using a combined 'click plus' stimulus with only a minimal increase in time. Such work provides an important step to increase the feasibility of clinical recording of the FFR, which would enable suprathreshold measures of auditory function to be assessed in neonates and young children.

Measuring Earlier Components of Auditory Brainstem Responses from Modified Speech

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Objectives: The auditory brainstem response (ABR) is a powerful measurement to assess hearing condition objectively and passively. ABR is typically elicited by repetitive clicks. Very recent research has derived ABR from naturally uttered speech, yet these approaches generally only reveal later ABR waves such as Wave Ⅴ, except for one study, for the first time derived clear Wave Ⅰ, Ⅲ, and Ⅴ from their "peaky" speech. However, their method involves great modification of the speech stimuli with computationally intensive pre-processing, which makes it sound less natural and unlikely to be used in real-time conversations. In our study, we implemented an alternative, computationally efficient speech modification algorithm - the transient enhanced speech, to elicit speech-derived ABR. Such an approach may allow for fast ABR-based hearing assessments in more natural conditions with little to no burden placed on the user. Moreover, studies have found behavioral benefits, e.g. higher intelligibility in noisy background, by emphasizing transients in speech. We first tested the unaltered and modified speech stimuli vs. clicks with an auditory periphery model to compare the model output ABR Wave Ⅰ, Ⅲ and Ⅴ. Using EEG, we then replicated results of the peaky speech. Finally we tested ABR with our transient speech.

Design: Ten subjects were recruited in this pilot study for replicating peaky speech (n = 2) and testing transient speech (n = 8). A section of audiobook was delivered via ER-2 insert earphones to both ears in 65 dB SPL. At the same time, EEG was recorded using the EP-Preamp with Multitrodes placed at Cz (non-inverting), right mastoid (inverting reference), and the high forehead (ground). Data were sampled at 25 kHz and offline high-pass filtered between 150 and 2000 for the speech-derived ABR using a first-order causal Butterworth filter.

Results: Observing the model output of 5 s of clicks and 16 s of peaky speech, transient speech and unaltered speech, we found the highest similarity of ABR morphology between clicks and peaky speech, with both showing distinct Wave Ⅰ, Ⅲ and Ⅴ. We also observed Wave Ⅰ, Ⅲ and Ⅴ in transient and unaltered speech, while with more variability especially in Wave Ⅰ. To further test our transient speech, we first demonstrated that the measured ABR derived from peaky speech replicated previous results. Compared to the ABR derived from peaky speech, the measured ABR derived from the transient speech revealed more prominent earlier peaks before Wave Ⅴ, although with more variability across subjects.

Conclusions: This study compared ABR elicited by different modified speech samples. We found that peaky-speech ABRs still resemble click ABRs the most, but its process requires heavy computation and results in unnatural-sounding output. The transient speech proposed by our study not only improves hearing in noisy environments as described in past studies, but also showed more prominent early ABR waves with lower computational complexity. Transient speech may serve as an alternative, real-time speech-enhancing algorithm to elicit ABR for hearing assessment and ultimately contribute to future clinical and real world implications.

Ear-Canal Calibration and Noise-Level Monitoring During Audiometry for Children

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Objectives: The accuracy of audiometric assessment in children is affected by inter-subject variation in the sound level in the ear canal and noise generated by the child. We predicted that greater real-ear-to-coupler differences and higher levels of self-generated noise would be associated with frequency-dependent inter-subject variability in pure-tone thresholds.

Design: We used an insert earphone with an integrated microphone to assess the level of the stimuli and ambient noise in the ear canal during an audiometric assessment for 30 children (age 4-12 years) with normal hearing and 10 children with permanent hearing loss. Results were compared in dB hearing level, dB sound pressure level, and dB forward pressure level.

Results: Inter-subject variability in pure-tone thresholds up to 30 dB (range 3 dB - 30 dB) was observed related to self-generated noise, primarily at 250 Hz and 500 Hz. Individual differences in ear-canal acoustics contributed to inter-subject variability up to 20 dB (range 2.7 - 20 dB) with the largest effects above 1000 Hz. The differences between dB SPL and dB FPL calibration were significant only at 4000 Hz.

Conclusions: Audiometric assessment techniques for children that account for individual differences in ear-canal acoustics and a child's self-generated noise can improve the accuracy of pure-tone thresholds from children. Further research will expand these findings to a larger group of children with mild bilateral hearing loss to examine the impact of these factors on diagnostic accuracy for hearing loss.

Characterizing High Frequency Hearing in 2-3-Year-Olds Born Preterm

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Objectives: Infants born preterm are at higher risk for hearing loss, particularly in the high frequencies, due to ototoxic drugs, hypoxia-ischemia, mechanical ventilation and hyperbilirubinemia. However, current newborn screening methods that use click stimuli may miss slight-mild and high frequency hearing loss. Our hypothesis is that all degrees of hearing loss important for speech perception can be detected using age-appropriate criteria for distortion product otoacoustic emissions (DPOAE), validated by high frequency audiometry in at-risk 2-3-year-old children.

Design: This longitudinal study is designed to develop a prediction model for risk of speech-language deficits at age 2-3 years for very and extremely preterm infants (born at 24-32 weeks gestational age). Predictive measures include chirp threshold ABR, DPOAE, audiometry, wideband absorbance, resting state functional MRI, speech evoked EEG, related to speech-language and preliteracy measures at 2-3 years. A total of 300 infants will be enrolled in 5 local NICUs and followed to age 3 years. In this preliminary analysis, 78 children (average 30 mos. corrected gestational age, range 24-42 mos.) were tested. The audiometry protocol included visual reinforcement (VRA) and/or conditioned play audiometry (CPA) to obtain minimum response levels (MRLs) between 1-8 kHz. DPOAE (10 f2 frequencies between 2-10 kHz) and wideband absorbance (.25 to 8 kHz) were tested with a clinical Titan system (Interacoustics). Published age-based normative levels for DPOAE level and SNR in well and premature infants were used as a priori normative criteria.

Results: The combined VRA & CPA protocol resulted in ear specific MRLs in 69% of children (n=54). For ears with normal DPOAE, MRLs of 20 dB HL approximated the 95th percentile, while median MRLs were 10 dB from 1-8 kHz. DPOAE tests were abnormal for level or SNR (>50% of test frequencies) in 40% of cases for one or both ears. Ear-specific pure tone MRLs were greater than 20 dB HL in one or both ears in 22% of cases. Most hearing losses had a middle ear component (59%), determined by bone conduction and wideband absorbance tympanometry. A high percentage (35%, n=5) were considered sensorineural (normal middle ear testing and/or elevated bone conduction). Of these, all but one had passed newborn hearing screening. One ear (6%) was an undetermined loss. Using normative criteria for DPOAE level and SNR, sensitivity of DPOAE for prediction of hearing loss > 20 dB at any frequency was 93%, while specificity was 77%. On-frequency correlations between MRLs at 2-8 kHz and DPOAE level were moderate (r=0.4 to 0.5, with stronger correlations at 4 and 8 kHz).

Conclusions: A very high prevalence of hearing loss, both conductive and sensorineural, was found in 2-3-year-old preterm graduates. Age-appropriate combined DPOAE levels and SNR were highly predictive of hearing levels > 20 dB HL. Wideband absorbance was an effective method to determine presence of

middle ear dysfunction to interpret DPOAE results. Updated results will be presented, as follow-up continues.

Characterizing Hearing in Service Members with Self-Reported Temporary Threshold Shifts
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Objectives: Service members (SMs) with a history of blast exposure often report difficulties with speech perception, even when they have normal thresholds. This phenomenon is often assumed to be related to the neural damage observed in the cochlea of mice and other animals when they are exposed to sounds that generate large temporary threshold shifts. Studies that have looked for correlations between objective measures of hearing performance and subjective reports of lifetime noise exposure have not generally found a strong relationship between these factors in civilian populations of young, normal-hearing listeners. However, recent studies on SMs have found a strong correlation between subjective hearing complaints and self-reports of temporary hearing changes occurring after exposure to loud sounds. The purpose of this study was to evaluate the relationship between hearing thresholds, self-reported temporary threshold shifts (TTSs), subjective hearing complaints, and objective measures of hearing performance in SMs with normal or near-normal hearing thresholds.

Design: Approximately 12,000 SMs volunteered to participate in the study as part of their annual hearing tests. In addition to completing the required threshold testing, participants were asked to complete a hearing survey that included 1) a question about TTS frequency ("Have you ever experienced a temporary change in your hearing (dullness or muffled sound) after exposure to a loud noise?"); 2) four hearing difficulty questions from the Tinnitus and Hearing Survey (THS); and 3) an 18-trial single-interval NoSpi tone detection test based on the Wilson clinical MLD test.

Results: Data were analyzed as a function of the better-ear hearing threshold at 4 kHz. The percentage of individuals who reported they had never experienced a TTS decreased systematically from 40% for those with -10 dB HL thresholds to 20% for those with +20 dB HL threhsolds. The THS and NoSpi scores of this TTS-free population were very good, and showed no threshold-related degradations until the better-ear threshold exceeded +5 dB. In contrast, individuals who reported at least one TTS, and, in particular, those who reported multiple TTS episodes per year, had TTS and NoSpi scores that were worse overall and systematically decreased with increasing thresholds from -10 dB HL to +20 dB HL. There was some evidence of an interaction between TTS frequency and years of service, suggesting that individuals who experience frequent noise-related hearing changes may have an increased risk of experiencing long-term hearing damage if they remain in a noise-exposed environment.

Conclusions: The results of this study suggest that SMs who frequently experience noticeable changes in their hearing after exposure to loud sounds tend to have more hearing complaints and poorer performance on an NoSpi detection task than SMs who experience these temporary hearing changes less frequently or not at all. This may reflect differences in noise exposure, but may also reflect individual differences in susceptibility to noise-related hearing damage. The results are consistent with the cochlear synaptopathy findings that have been observed in animals and they suggest that self-reported TTS should be monitored as a potential risk factor for individuals enrolled in hearing conservation programs.

Manual and Automated ABR Analysis: Reliability, Agreement and Efficiency

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Objectives: This study compared the reliability, agreement, and efficiency of automated and manual examiner-driven analyses of (auditory brainstem responses) ABRs recorded from blast-exposed and neurotypical military Veterans. The aims of the study include the following: Aim 1. Assess the extent to which automated, and examiner driven analyses agree with respect to the determination of peak latency and amplitude values of the ABR's waves I, III and V. Aim 2. Evaluate the test-retest reliability of automated and examiner driven analyses for the selection of peak latency and amplitude values of the ABR's waves I, III and V. Aim 3. Examine the efficiency of the two analysis methods as a function of noise and waveform quality.

Design: The ABR data included in this analysis were elicited monaurally via high intensity click stimuli from 194 Veterans between the ages of 20-50. Participants had normal/near normal pure tone thresholds from 250-8000 Hz and were categorized as having either a positive history of blast exposure or no reported exposure to high intensity blasts. A total of 1,532 tracings were included in this analysis. To evaluate differences in peak selection across methods, accounting for reliability, a multivariate repeated measures model was selected. The independent variable (IV) was method of analysis (automated vs. examiner-driven), a between subject's factor, and the dependent variable (DV) was the peak component value of interest (i.e., latency or amplitude), a within subject's factor, for waves I, III, and V of the ABR. Covariates tested in the model included age, ipsilateral vs. contralateral stimulation, residual noise level, and stimulus intensity. A series of Bland-Altman analyses, including a random effects model to account for the repeated measures design, were conducted to assess (1) intra-examiner and (2) inter-examiner agreement for the manual analysis. Intra-examiner reliability was also evaluated for the automated analysis, which was only completed by one examiner. Thus, inter-examiner reliability could not be evaluated. Finally, the time spent performing peak selection was tracked for one examiner and compared across both methods.

Results: A high level of reliability was noted across methods, with wave V being the most reliable peak component for both latency and amplitude, followed by wave I, then wave III. Bland-Altman plots indicated a high level of agreement across methods. For each variable at least 95% of the differences were within the mean ¬±1.96 SD. Furthermore, residual noise levels did account for a significant amount of the variance observed across measures. The automated analysis was significantly more efficient for tracings with low levels of residual noise; however, the time spent during peak selection for tracings with higher levels of residual noise was similar across the two methods.

Conclusions: In this study, reliability, agreement, and efficiency were systematically evaluated across an examiner driven and computerized analysis of ABR data. The automated analysis was found to be reliable and had high agreement with the examiner-driven method. Thus, automated analyses of ABR data are worth considering as they have the potential to limit examiner bias and may be more efficient when evaluating ABR data. However, tracings with significant levels of artifact may require further review by a trained examiner. Factors that can influence agreement and/or reliability also will be described, including residual noise levels, signal to noise ratio, replicability of wave V, and gestalt waveform morphology.

Hearing Impairment in the Extended High Frequencies in Children

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Objectives: Hearing loss during childhood has deleterious consequences on all aspects of development, including speech-language communication. Hearing impairment in the extended high frequencies (EHFs; > 8 kHz) can occur despite clinically normal hearing. However, the consequences of reduced EHF hearing in children with an otherwise normal audiogram are not known. The objective of the present study was to examine the effects of reduced EHF hearing in children. Specifically, two questions were addressed: (1) Does reduced EHF hearing affect speech-in-noise recognition; and (2) Is cochlear functioning in the standard frequencies altered in children with reduced EHF hearing?

Design: Participants with reduced EHF hearing were assigned into cases using a case-control design. Reduced EHF hearing was defined as hearing thresholds greater than 20 dB in at least one of the EHFs (10, 12.5, or 16 kHz). Audiometry and speech recognition thresholds (SRTs) using the digit triplets test were measured from 542 participants (4 - 19 years; n = 1084 ears), and distortion product otoacoustic emissions were recorded in 48 children (n = 96 ears).

Results: Thirty-eight children had reduced EHF hearing impairment regardless of a clinically normal audiogram. Hearing in the EHFs can decline as early as 9 years of age. Linear mixed-effects model, with adjustments for age effects, revealed that children with EHF hearing impairment had higher (poorer) mean SRT than the control group (effect size = small). The overall magnitude of distortion product otoacoustic emissions was lower for children with reduced EHF hearing (effect size = medium). In addition, the pure-tone average for standard audiometric frequencies was relatively higher (poorer) for EHF-impaired children (effect size = small).

Conclusions: Hearing impairment in the EHFs is common in children despite clinically normal hearing. EHF impairment is associated with poor speech-in-noise recognition and pre-clinical cochlear deficits in the lower frequencies where hearing thresholds are normal. This study highlights the clinical need to assess EHF hearing in children.

Electroencephalographic Evaluation of the Efficacy of Split-Processing in Hearing Aids

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Objectives: To evaluate the neural consequences of split-processing in hearing aid wearers. Split-processing is a new approach to hearing aid design where the incoming sound is split into entirely separate front and back signal streams. As such, split-processing enables hearing aids to process sounds coming from the front and the back independently, with different gains, time constants, and noise reduction settings. In this study, we speculated that split-processing may also limit the acoustic features that would otherwise be common to sounds processed as a single input stream (e.g., amplitude envelope, spectral shape). According to principles of auditory scene analysis, we expected split-processing to enhance the brain's representation of speech sounds arriving from the front separate from surrounding babble noise. By extension, we hypothesized that split-processing directionality would reduce the effort associated with understanding speech in noise compared to omnidirectional or non-split directional microphone modes.

Design: To assess the first hypothesis, we measured the mismatch negativity (MMN)-an electroencephalographic response evoked when the auditory system detects an unexpected sound. Recent interpretations of the MMN suggest the signal reflects a prediction error used by the brain to update its internal representation of an auditory source in light of discrepant information. As such, stronger representations of a frequent sound were expected to elicit stronger MMNs to the unexpected sound. The MMN was measured in 14 listeners (mean age = 68 years, SD = 15, 7 female) with a bilateral symmetrical sensorineural hearing loss in response to a natural phonetic contrast (/ba-ba/ versus /ba-da/) presented at 65 dB SPL from the front. At the same time, recordings of 4-talker babble were played from two loudspeakers in the back (135¬∞ and 225¬∞ azimuth) at individualized SNRs. To assess the second hypothesis, we measured alpha band (8-12 Hz) EEG activity, considered a proxy for listening effort, in the same group of listeners as they performed a speech-in-noise test (Repeat-Recall Test). For both measures, we compared a full feature version of a hearing aid with split-processing directionality to a version that did not have split-processing. The non-split hearing aid was programmed and tested in a standard omnidirectional microphone mode (non-split-omi) and in an automatic adaptive directional microphone mode (non-split-dirm). Hearing aid conditions were compared within-subjects using linear mixed effects models.

Results: As expected, hearing aid condition had a significant effect on the amplitudes of listeners' MMN responses (œá2(2) = 8.17, p = 0.017), where post-hoc contrasts confirmed that MMN amplitudes were significantly enhanced by split-processing directionality. In addition, alpha power was reduced when listeners performed the speech-in-noise test in the split-processing mode compared to the non-split-omni or non-split-dirm modes (œá2(2) = 25.30, p< 0.001).

Conclusions: Split-processing directionality enhanced listeners' tracking of changing phonemes from a single talker in a cocktail party type situation. Lower alpha activity measured in the split-processing mode compared to the non-split modes, along with the passive nature of the MMN experiment, further suggests that the benefits of split-processing are bottom-up in nature.

PODIUM SESSION V: COGNITION, MENTAL HEALTH, AND PSYCHOSOCIAL CONSIDERATIONS FOR HEARING HEALTHCARE

Association of PTA and Speech-in-Noise Performance with Cognitive Decline

New Investigator Presentation

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Objectives: Previous studies have demonstrated the associations between hearing loss and cognitive decline, however hearing loss has primarily only considered peripheral hearing as measured by pure-tone audiometry. Evidence regarding speech-in-noise performance on cognitive decline is more limited. We examined the longitudinal associations of both audiometric hearing and speech-in-noise performance with cognitive decline in a longitudinal study among community-dwelling older adults.

Design: Using data from 702 Baltimore Longitudinal Study of Aging participants aged ≥60 years, we examined the association of poorer hearing with level and slope of cognitive function (global function, language, executive function, memory, attention, visuospatial). Hearing loss was defined as pure-tone average (PTA) >25 decibels in the better hearing ear. Speech-in-noise performance was assessed by the Quick Speech-in-Noise (QuickSIN) test, and participants had poorer QuickSIN if at or below-median and better if above-median. Linear mixed effects models with random intercepts and slopes were used for differences in baseline cognitive performance and cognitive decline over time by hearing status. Models were adjusted for demographic, lifestyle and baseline comorbidities or health factors. QuickSIN models were additionally adjusted for PTA.

Results: Over a mean follow-up of 3.5 years, participants with audiometric hearing loss showed similar baseline cognitive performance but steeper decline in global cognitive function (difference in rate: -0.09 SD, 95% CI: -0.11, -0.06), language (difference: -0.04 SD, 95% CI -0.06, -0.02), executive function (difference: -0.04 SD, 95% CI: -0.07, -0.02) and attention (difference: -0.04 SD, 95% CI: -0.07, -0.02) but not in memory. Participants at or below-median QuickSIN score had poorer baseline cognitive performance across all domains and steeper decline in global cognitive function (difference in rate: -0.08 SD ,95% CI: -0.11, -0.06), language (difference: -0.03 SD, 95% CI: -0.05, -0.01), memory (difference: -0.03, 95% CI: -0.05, -0.00), attention (difference: -0.04 SD, 95% CI: -0.06, -0.02) and executive function (difference: -0.04 SD, 95% CI: -0.06, -0.01).

Conclusions: Inclusion of speech-in-noise testing alongside audiometry in future research may highlight the potential for speech-in-noise performance to supplement existing neurocognitive test batteries and potentially serve as an early marker for cognitive decline in study of hearing management for dementia prevention and intervention.

Hearing Loss and Subjective Cognitive Function in the ARIC-Neurocognitive Study

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Objectives: Subjective cognitive decline (SCD) and complaints (SCC) among adults with normal cognition are important for quality-of-life and may predict future cognitive decline and progression to mild cognitive impairment/dementia. Hearing loss could be associated with SCD/SCC through increased cognitive load. Few population-based studies have examined this association, and these studies have limitations, including measurement of hearing loss by self-report. When both the exposure (hearing loss) and the outcome (SCD/SCC) are self-reported, there is the possibility of a 'same-source bias', or a spurious association because the measurement error for both exposure and outcome are correlated. We estimated the association between hearing loss and SCD and SCC in the biracial Atherosclerosis Risk in Communities Neurocognitive Study (ARIC-NCS) using 3 measures of hearing - audiometry, self-reported hearing and speech-in-noise performance.

Design: Cross-sectional study in ARIC-NCS participants with subjective cognitive function and hearing data who tested within the normal range on neurocognitive exams at the 2016-17 clinic visit. SCD was defined as self-report of persistent decline in memory (yes/no) and SCC was assessed using 9 questions (e.g., "Do you have any complaints concerning your memory?", modeled as a count variable, range 0-9). Audiometric hearing was defined as a better-ear 4-frequency pure tone average, modeled continuously and as a binary variable [>25 dBHL (hearing loss) vs. ≤ 25 dBHL (normal hearing)]. Speech-in-noise performance was measured using the Quick Speech-in-Noise test [(average of two lists, modeled continuously and as a binary variable (worst quartile of performance compared to top 3 quartiles)]. Self-reported hearing was measured using the question, "Which statement best describes your hearing without a hearing aid?" and modeled as an ordinal variable [excellent/good (reference group); little trouble; moderate trouble/a lot of trouble/deaf]. Poisson models with robust standard errors and negative binomial models were used to estimate the prevalence ratios (PR) and 95% confidence intervals (CI) of SCD, and the prevalence rate ratios (PRR) and 95% CI's of SCC, by hearing status, adjusting for demographic and clinical covariates.

Results: In 2,536 participants (mean age 79.3¬±4.4 years, 60% female, 20% Black), after full adjustment, self-reported moderate or greater trouble with hearing (vs. excellent/good hearing) was associated with a 30% increase in the prevalence of SCD (PR=1.30; 95% CI:1.12, 1.51) and prevalence rate of SCC (PRR=1.30, 95% CI:1.17, 1.45). Audiometric hearing and speech-in-noise performance were not associated with SCD or SCC. This finding was robust to use of alternate cutpoints to define audiometric hearing loss (e.g., >40 dB HL).

Conclusions: Among older adults with intact cognition, self-reported hearing was associated with SCC and SCD, but audiometry and speech-in-noise were not. Compared to objective measures of hearing, self-report includes personal perception based on an individual's social environment. Use of self-report to approximate audiometric hearing warrants caution, particularly when the outcome is also self-reported, as our findings suggest the association between self-reported hearing and SCC may be due to correlated measurement error (e.g., personality traits related to whether a person has concerns about their cognition also lead them to have concerns about their hearing).

Associations between Audiometric Hearing, Brain MRI, Cognition and Speech-in-Noise Performance

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Objectives: Speech understanding is fundamental to daily life. It involves both bottom-up process that transmits auditory signals to the cortex and top-down process that involves cognition to aid in the interpretation of auditory signals. Difficulties understanding speech in noise are prevalent among older adults. However, population-based evidence from large-scale epidemiologic studies to investigate mechanisms underlying speech understanding is limited. This study aims to investigate cross-sectional associations of audiometric hearing, brain magnetic resonance imaging (MRI) measures and cognitive function with speech-in-noise performance among community-dwelling older adults.

Design: The Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study is a randomized controlled trial partially nested within the Atherosclerosis Risk in Communities (ARIC) Study. ACHIEVE enrolled dementia-free older adults aged 70-84 years with mild to moderate hearing loss. We studied 441 ACHIEVE baseline (2018-19) participants with hearing loss and additional 179 ARIC Visit 6/7 (2016-17/2018-19) participants with normal hearing and comparative age and cognitive status (mean age: 77¬±4 years, 56% female, 18% black). Speech-in-noise was assessed by the Quick Speech-in-Noise (QuickSIN) test. Total score ranges from 0-30 with higher score indicates better performance. QuickSIN score was analyzed categorically (top 3 quartiles vs. the lowest quartile). Pure-tone average (PTA) was calculated by averaging hearing thresholds at 0.5, 1, 2 and 4 kilohertz in better-hearing ear and was

scaled to every 10 decibels (dB). Brain MRI measures included volumes of regions of interest, white matter hyperintensities (WMH) as well as white matter microstructural integrity, using fractional anisotropy (FA) and mean diffusivity (MD) obtained from diffusion tensor imaging. These measures were standardized to Z-scores and analyzed continuously. Global and domain-specific (Language; Memory; Executive function) cognitive performance was assessed by a battery of cognitive tests. We used multivariable-adjusted Poisson regression with robust error variance to estimate prevalence ratios (PR) of being in the worst quartile vs. top 3 quartiles of QuickSIN score. Separate models for each exposure of interest (Audiometric hearing; Brain MRI; Cognition) and a combined model with all the exposures were run. Models adjusted for demographic, lifestyle and disease factors.

Results: In separate models, the prevalence of being in the worst quartile of QuickSIN score (vs. top 3 quartiles) was associated with (i) audiometric hearing [every 10 dB worse associated with a PR=2.18 (95% CI: 1.82, 2.61)]; (ii) brain MRI measures [every 1 standard deviation (SD) worse temporal lobe volume, PR=1.36 (95% CI:1.01, 1.84) and WMH volume, PR=1.16 (95% CI:1.02, 1.33)]; and (iii) cognitive performance [every 1 SD worse global cognitive performance, PR=1.38 (95% CI:1.17, 1.63), language, PR=1.36 (95% CI:1.11, 1.65) and executive function, PR=1.31 (95% CI:1.12, 1.53)]. In the combined model, worse audiometric hearing and cognitive performance, but not brain MRI measures, were associated with worse speech-in-noise performance.

Conclusions: Among dementia-free individuals, audiometric hearing and cognitive performance are associated with speech-in-noise performance, independent of each other. Brain MRI measures do not significantly add to the prediction of speech-in-noise performance. The ongoing follow-up of the ACHIEVE study will facilitate understanding of speech-in-noise performance over time and inform hearing interventions.

How do Audiologists Detect and Discuss Mental Wellbeing?

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Objectives: Mental health is essential to overall wellbeing, but there has been little research on how to approach mental health in the audiology setting. In order to detect and discuss wellbeing with their clients, audiologists require an understanding of mental health, the skills necessary to detect the signs of low wellbeing and the confidence to engage in these sorts of discussions. The purpose of this study was to investigate the current knowledge, beliefs and practices of audiologists in addressing the mental health needs of adults with hearing loss.

Design: A 22-item survey using open and closed-ended questions was completed by 95 audiologists using a cross-sectional study design. The survey comprised three sections: (1) ten demographic and professional training questions; (2) three case vignettes to explore symptom-management activities, i.e. how audiologists currently respond to symptoms of mental illness in the audiology setting; and (3) nine questions investigating current beliefs and practices of audiologists in delivering support to people with mental health concerns.

Results: When asked to describe their usual clinical course of action in response to the vignettes, almost half of the audiologists described actions that address only the audiological symptoms and not concerns related to mental wellbeing. Where audiologists described how they would provide mental wellbeing support, they described modifications to the audiological rehabilitation program including involving

significant others in the rehabilitation process, recommending additional support outside of the audiology setting (such as General Practitioners or psychologists), and providing emotional support and counselling. Most audiologists' indicated that a better understanding of clients' emotional and mental health would improve hearing-related services but less than one-third routinely ask clients about their psychological well-being. Barriers to delivering mental wellbeing support included feeling out of their depth (56.6%), time/caseload pressures (55.3%), and the perception that the provision of emotional support was not within an audiologist's scope of practice (31.6%). Audiologists described a desire to refer clients to mental health professionals, yet highlighted significant barriers, including not knowing who to refer to (54.7%), when to make a referral (49.3%), or how to make a referral (38.6%). Audiologists overwhelmingly (96%) indicated that they would like to develop their knowledge and skills associated with the provision of emotional and mental health support in the audiological setting.

Conclusions: Audiologist are well placed to provide metal wellbeing support, yet they both require and desire further training to improve their provision of mental health support in the audiology setting.

Hearing/Vision Impairments and Social Isolation Over Time in Older Adults

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Objectives: Social isolation is prevalent among older adults and can be debilitating for mental and physical well-being. Little is known about the long-term impact of sensory impairment on social isolation. The objective of this study is to quantify the longitudinal associations between hearing, vision, and concurrent hearing and vision impairment (dual sensory impairment) and social isolation over 8 years among older adults.

Design: Data were from the National Health and Aging Trends Study (NHATS), a nationally - representative prospective cohort study (2011-2019) of Medicare beneficiaries aged 65 years and older in the contiguous United States. Social isolation was measured by a binary indicator that incorporated four domains of social isolation: living arrangement, core discussion network size, religious services attendance, and social participation. Functional hearing and vision at baseline were measured by self-report and modeled as a four-level categorical variable (no impairment (ref.), functional hearing impairment only, functional vision impairment only, functional dual sensory impairment). Associations between functional sensory impairments and odds of overall social isolation and odds of specific domains of social isolation over 8 years were assessed using multivariate generalized logistic mixed models. Models were adjusted for age, sex, education, race/ethnicity, smoking, and self-reported history of chronic conditions (diabetes, hypertension, heart attack, heart disease, lung disease, cancer, and stroke).

Results: Among 5,552 participants, 18.9% reported functional hearing impairment, 4.8% reported functional vision impairment, and 2.3% reported functional dual sensory impairment. Over 8 years, functional hearing impairment was associated with 28% greater odds of social isolation. Specifically, participants with functional hearing impairment were more likely to live alone and fail to engage in social activities. A similar pattern of association was observed for dual sensory impairment; however, estimates

lacked precision and so did not reach the threshold for statistical significance. No associations were observed between functional vision impairment and social isolation.

Conclusions: Over 8 years, functional hearing impairment was associated with higher likelihood of social isolation. Older adults with hearing impairment may be a clinically important subgroup to monitor for social isolation and related mental health outcomes. Interventions for increasing social support and social participation may be especially valuable for older adults with hearing impairment. Future investigations should continue to determine the longitudinal impact of hearing and vision sensory impairments on social isolation in the aging population.

Mental Health Among Sensory Impaired Individuals During COVID-19 Lockdown Measures

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Objectives: During the SARS-COV-2 pandemic, lockdown and social distancing measures were initiated to mitigate disease spread. Research has found that these measures were associated with increased psychological distress, depression and loneliness. Importantly, lockdown measures may affect individuals with disabilities more severely. Hearing and vision impairment are highly prevalent chronic conditions in aging adults that affect peoples' daily lives. People with a hearing or vision loss report reduced social support and participation and greater loneliness as well as poorer mental health and well-being. Mental health problems may have been exacerbated by COVID-19-related lockdown measures, and limitations of in-person contacts may affect those with sensory impairments more severely. We aimed to determine whether hearing and/or vision impairment were associated with worse mental health and well-being during lockdown measures in Spring/Summer 2020 in Wisconsin.

Design: This study is based in participants of the Survey of the Health of Wisconsin COVID-19 community impact survey (May-July,2020). We assessed measures of self-reported current mental health, psychological well-being and hearing and vision impairment. We asked participants to rate (excellent, very good, good, fair, poor) their hearing (with hearing aid if used) and vision (with glasses, if used) and quantified hearing and/or vision impairment, respectively, if they reported fair or poor function. Logistic regression models with hearing and vision impairments as determinants and multiple mental health and well-being outcomes adjusted for age, gender, race, education, heart disease, hypertension, hyperlipidemia and diabetes were used.

Results: We included 1341 participants (64% women, aged 20-92 years, n=144 hearing-impaired, n=141 vision-impaired). Hearing impairment was associated with increased odds of taking depression medications (odds ratio=1.72; 95% confidence interval=1.07-2.73) and reporting loneliness (1.80;1.05-2.98). Vision-impaired individuals were more likely to have symptoms of a generalized anxiety disorder (2.10; 1.32-3.29) and depression (2.57; 1.58-4.11), to be taking depression medication (1.75;1.13-2.68)

and to report loneliness (1.65; 1.00-2.64) and hopelessness (1.45;1.01-2.08). When excluding individuals with a history of depression (n=250), effects were similar, with the exception of vision models on anxiety disorder, where the effect size decreased to a trend level. Moreover, exploratory analyses revealed that individuals with a hearing and/or vision impairment were less likely to choose walking as a coping strategy, which was among the 5 mostly commonly used coping strategies in this study.

Conclusions: In a global pandemic, it is important to identify vulnerable populations that may be disproportionately affected by the disease and/or associated prevention measures in order to provide adequate resources and care to people with chronic conditions and disabilities. We found that individuals with sensory impairments experienced worse mental health and psychological well-being during the SARS-COV-2 pandemic in early Spring/Summer of 2020, a time when COVID-19 pandemic lockdowns were implemented. Vision and hearing-impaired individuals were more affected on measures of depression, anxiety (vision only), loneliness and hopelessness (vision only) compared to sensory-unimpaired, identifying them as a particularly vulnerable population. This expands limited research on mental health of individuals with sensory loss during the COVID-19 pandemic to population research covering the adult lifespan. Future longitudinal studies should determine underlying reasons and interventions to mitigate this population's disadvantages.

Effect of Hearing Loss on Facial Expressions of Emotion

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Objectives: In Audiology, research on emotional responses is in its infancy. Existing research shows a reduced range of emotional responses in individuals with hearing loss, and a connection between emotional response and feelings of social disconnectedness. Hence, it is important to study emotional responses in hearing loss. So far, emotional responses have mostly been studied using subjective measures. We decided to supplement this with an objective measure, i.e., use of facial expressions to measure emotional responses. This measure provides us the time course of the emotional response, is free from subjective bias, and can help identify the emotion in addition to its intensity. We investigated emotional responses to speech in noise because this is a situation that individuals with hearing loss complain about the most. Our aim was to investigate the effect of hearing loss on the facial expressions of emotion. We hypothesized that compared to the normal hearing condition, hearing loss condition will increase the emotions of confusion and frustration. We also simultaneously measured pupil responses to obtain a measure of objective listening difficulty/ effort. We expected to see an increase in pupil dilation in the hearing loss condition as compared to the normal hearing condition.

Design: We studied emotional responses in 33 young adults (16 F) with normal hearing. Participants listened to and repeated sentences in quiet and in signal-to-noise ratios (SNR) of -3, 0, and +3 dB with reference to individual SNR-50 scores. They performed the task in the normal hearing (NH) and simulated hearing loss (HL) condition. We measured their facial movements and analyzed them through an automatic facial expression recognition algorithm. Specifically, we analyzed the emotions of confusion and frustration because these emotions were seen previously in literature when individuals face challenging situations that cause them cognitive disequilibrium. We also recorded their pupil responses simultaneously. We also asked them to rate their perceived emotions and listening effort using subjective rating scales. We conducted statistical analysis using linear mixed effects model. The different SNRs were the independent variable and the emotional responses obtained using facial expression recognition

software, subjective rating scale responses, and pupil responses were the dependent variables. We added a random intercept for subjects.

Results: We found a significant main effect of both SNR and condition (NH vs HL) with the emotions of confusion and frustration increasing both with SNR degradation and during the HL condition. For the pupil responses, we saw the effect of SNR approach significance, and a significant effect of HL. Subjective ratings of confusion and frustration showed a significant increase in these perceived emotions with increasing listening difficulty. Listening effort rating also showed a similar increasing trend with increasing listening difficulty or worsening speech recognition performance.

Conclusions: We conclude that facial expressions of confusion/ frustration increase during the hearing loss condition. Hence, this method shows promise as an objective way to measure emotional responses during difficult listening situations. This method could have applications in the objective measurement of emotional responses and listening difficulty in the real-world.

Cognitive Deficits and Speech Understanding in Quiet and Noise

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Objectives: Untreated hearing loss has been associated with a significant increase in the likelihood of cognitive decline in older adults. While the mechanism underlying this association is unclear, this provocative finding poses challenges for public health and audiologic practice. One key issue is that despite this association, not all adults with hearing loss develop cognitive issues. Thus, use of hearing thresholds alone may not be a meaningful way to determine which patients are at risk for cognitive issues and should be referred accordingly. With regard to audiologic practice, it would be ideal if there were measures within the routine test battery that might be sensitive to cognitive status and remain within audiologists' scope of practice. We have argued that measures of speech in noise (SIN) should replace word-recognition in the audiologic test battery. SIN measures may be a particularly appropriate audiologic test to potentially flag patients with cognitive deficits, because SIN performance has been widely correlated with measures of executive function. Here we address this issue by examining performance on tests of speech recognition in quiet and noise in patients with and without diagnosed cognitive deficits.

Design: Data were obtained retrospectively from 5084 patients who underwent audiometric assessment at Stanford University. Each of these patients completed pure-tone audiometry, NU-6 word recognition in quiet (WRQ) and the QuickSIN. All tests of speech recognition were presented at levels designed to maximize audibility. We examined ICD-10 diagnosis codes to identify patients with a diagnosis of Alzheimers disease, dementia, or mild cognitive impairment. 210 patients were identified and were categorized as a 'cognitive deficit' group. Of the remaining patients, we used ICD-10 codes to remove individuals with a history of vascular disorder or diabetes. 3471 patients remained and were classified as a control group. We then stratified patients within each group according to their degree of hearing loss and compared WRQ scores and QuickSIN signal-to-noise-ratio (SNR) loss.

Results: For both the control group and cognitive deficit groups, WRQ scores and QuickSIN SNR loss deteriorated with increasing hearing loss. WRQ scores did not differ between the two groups, suggesting equivalent performance in quiet between patients with cognitive deficits and those with hearing loss alone. In contrast, QuickSIN SNR losses in the cognitive deficits group were poorer at all degrees of hearing loss than those in the control group. These between-group differences appeared to be of a similar magnitude regardless of degree of hearing loss.

Conclusions: Taken together, these results suggest that traditional measures of word-recognition are incapable of distinguishing between patients with and without a cognitive deficit. In contrast, patients with cognitive deficits performed significantly worse than controls on understanding SIN. While preliminary, these results suggest that measures of SIN in conjunction with hearing acuity have potential to triage which patients with hearing loss may be at risk for cognitive decline. Finally, these data provide further evidence for the idea that SIN should replace WRQ in most routine audiologic assessments.

PODIUM SESSION VI: SPEECH PROCESSING AND PSYCHOACOUSTICS

Mechanisms Underlying the Association between Speech-in-Noise Perception and Extended High-Frequencies

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Objectives: People with clinically defined normal hearing frequently report difficulty hearing in noise. They often leave audiology clinics with no diagnosis to explain the difficulty they experience. Substantial evidence in adults and children demonstrate that extended high frequency (EHF; > 8 kHz) hearing, beyond the currently tested range of clinical audiometry, contributes to speech-in-noise (SIN) perception. However, the mechanisms underlying this association are not yet clear. Our preliminary data in children and adults with normal conventional audiograms, yet have difficulty understanding SIN suggests 3 hypotheses: 1) loss of audibility and/or broadened auditory filters at EHFs results in impaired SIN perception; 2) EHF hearing loss (EHFHL) is an indicator of damaged outer hair cells (e.g., reduced amplification or non-linearity) outside the EHF range of hearing that results in impaired SIN perception; and 3) factors causing hearing loss at EHFs may also cause deafferentation (e.g., loss of synapses, auditory nerve fibers and/or hair cells), resulting in impaired SIN performance.

Design: We reviewed data collected through multiple studies in our laboratory using standard (0.25-8 kHz) and EHF (9-16 kHz) audiometry, subjective reports of listening difficulties, digits-in-noise test, Bamford-Kowal-Bench (BKB)-SIN test, Listening-in-Spatialized-Noise task (LiSN-S), double-evoked TEOAEs with chirp stimuli (0.71-14.7 kHz), and Wideband Middle-Ear Muscle Reflex (MEMR) in children and adults (7-65 y/o; N=344, updated results will be presented as participants continue to be enrolled).

Results: Results of these studies converge on 3 main findings: 1) EHFHL is a significant predictor of both subjective and behavioral measures of difficulty understanding SIN ($p<0.01$ to 0.001), suggesting that cochlear function in the EHF range may be an "early flag" for impaired SIN performance; 2) individuals with EHFHL had a mean elevation at standard frequencies of 3.8 dB ($p<0.001$). This elevation was significantly correlated with poor SIN performance ($r=0.32$, $p<0.001$), suggesting possible involvement of standard frequencies in impaired SIN perception despite normal conventional audiograms. Moreover, chirp-TEOAE revealed reduced SNR at standard frequencies in individuals with EHFHL relative to those with normal EHF hearing ($p=0.04$ to $p<0.01$). This finding suggests that EHFHL might reduce the necessary input for the proper functioning of mechanisms in cochlear regions corresponding to standard frequencies, resulting in impaired SIN performance. In addition, TEOAE-SNR for EHFs was a significantly better predictor of impaired SIN than pure-tone thresholds ($p<0.01$), suggesting that difficulty listening in noise might be related to damaged hair cell function that is not yet manifested in pure-tone thresholds; and 3) individuals with better EHF hearing displayed a steeper MEMR growth compared to individuals with poorer EHF thresholds ($r= -0.36$; $p<0.001$). Steeper MEMR growth was also significantly correlated with better LiSN-S scores ($r=0.20$, $p=0.006$). LiSN-S and EHF thresholds were also significantly correlated ($r=0.27$, $p<0.01$). These findings imply the possible involvement of synaptic or neural mechanisms in the impaired SIN perception observed in individuals with EHFHL.

Conclusions: Overall, outcomes of this study suggest multiple mechanisms at play in how EHFHL causes difficulties in SIN perception. Better understanding of the impact of EHFHL on auditory communication abilities of children and adults would motivate efforts to improve hearing conservation, rehabilitation and future treatment.

Auditory-Spatial Perception and Memory in Children with Hearing Loss

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Objectives: The objective of this study was to examine spatial listening in children with hearing loss (HL) compared to peers with normal hearing (NH).

Design: A total of 19 children with NH (9 to 15 years) and 12 children with bilateral, symmetrical HL (11 to 15 years) listened to and learned words originating from multiple, equally-spaced locations along the 360-degree horizontal plane. The children with HL used hearing aids fit to DSL prescriptive targets and programmed to provide omnidirectional and directional amplification in separate memories. All of the children completed a traditional word recognition task as well as a multi-word recognition task in which 12 words were presented in series prior to verbal repetition. Stimuli were presented at 70 dB SPL from 6 equally-spaced locations. Cafeteria noise was presented at 67 dB SPL from 3 additional locations for a +3 dB SNR. Fifteen of the children with NH (9 to 14 years) completed an additional task. They learned to associate 5 nonsense words with 5 novel pictures through a process of trial and error. The words were presented at 70 dB SPL in quiet from 5 equally-spaced locations. Next-day retention of the word/picture associations was compared to performance during the learning task.

Results: On average, recognition of individual and multiple words by the children with NH was similar for each source location suggesting omnidirectional sensitivity to speech. For the children with HL, recognition of individual words was similarly omnidirectional but ~20% poorer overall. Performance improved with directional microphones for words from the front but decreased for words from behind resulting in no change in overall performance. For the multi-word recognition task, performance was also

~20% poorer than normal in the children with HL. However, the results revealed a left-side deficit in which recall for words presented from the left was 23% poorer than for words presented from the right with both omnidirectional and directional amplification. Finally, word learning in children with NH was equally good from all directions during the learning task (~70%) while next-day recall was 27% poorer for words presented on the left during the learning task compared to words presented on the right.

Conclusions: While recognition of individual words was unaffected by source location, a left-side deficit unique to hearing loss became apparent when children attempted to retain several words in memory for a few seconds. A similar left-side deficit was observed in children with NH who attempted to retain nonsense words in memory for 24 hours. These results suggest that memory for speech perceived on the right and processed first by the left hemisphere in the brain is better than for speech perceived on the left and processed first by the right hemisphere. If a left-side deficit is normal for some auditory tasks, non-traditional amplification strategies may be necessary to match the performance of children with HL to their peers with NH.

Does the Ear Turn Itself Down Before Speaking?

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Objectives: Separating the sounds of the environment from self-generated noise is critical for survival. This skill is particularly relevant for humans due to the overlap in spectral content between one's own, and their conversational partner's, speech. Solving this problem online requires knowledge about the timing of impending speech, which can be conveyed through the efferents to influence afferent activity. Two candidate efferent systems run from the brainstem to the ear: the middle ear muscle reflex (MEMR) and medial olivocochlear reflex (MOCR). Because these reflexes influence auditory sensation at very early stages, they are particularly relevant for attenuating self-generated noise. Evidence from animal models and humans already suggests an MEMR role in attenuating sound energy of own speech, but little is known about contributions of the MOCR. Using novel methods developed in our lab that help delineate the relative activity of the two efferent systems, we investigated the role of the MOCR in preemptively attenuating cochlear activity in anticipation of hearing one's own speech. We hypothesized that, like the MEMR, the MOCR will show elevated activity prior to speaking compared to non-speaking trials.

Design: To minimize confounding MEMR activity, 4 young normal-hearing participants (prospective 20) were first screened with a click-based MEMR test where the MEMR magnitude zero-crossing frequency was identified. At this frequency, the MOCR eliciting and otoacoustic emission (OAE) evoking toneburst (1/3rd octave wide; 70 dB ppSPL; 62.5 Hz) was generated in the frequency domain based on individual ear canal and middle ear transfer functions. During the experiment, tonebursts were played bilaterally before (2 s) and after an icon of an everyday item was presented on a screen (2 s; 50% probability), and until the icon was replaced by a question mark (2 s). After the question mark, participants were asked to name this icon. As a control, there were silent trials that followed the same time course but included a blank screen instead of an icon that indicated the participants should not speak (50% probability). We expect the tonebursts to elicit MOCR reflexively, captured by TBOAEs, and speech planning to enhance this activation in the moments preceding the display of the icon.

Results: Initial piloting (n=3, and 4 unique participants) has indicated the efficacy of tonebursts in indexing MOCR activity. Additionally, the wideband MEMR test functions reliably in selecting frequencies of least MEMR interference for the tonebursts. Using the main experimental paradigm, data has been

gathered from four participants. Analysis of the complete set of data will indicate the activity, if any, of the MOCR prior to speech. Further results will be presented at the conference.

Conclusions: This study will indicate whether or not the MOCR is recruited prior to one's own speech in order to turn down the cochlear amplification process to the anticipated signal. A positive result would further demonstrate the extent to which even very peripheral aspects of sensation can be modified in real-time to refine our sensory experience, which is an exciting concept to be explored in multiple fields of research.

Phonological Similarity, but not Vocoding, Impairs Learning of Verbal Sequences

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Objectives: Children with cochlear implants often struggle to learn language. This struggle could arise from the degraded auditory input an implant provides and/or from increased phonological similarity that comes with a lack of awareness of the full set of phonological features which distinguish speech sounds from one another. As a first step toward dissociating these possibilities, we manipulated both the auditory input quality and the phonological features of nonsense syllables in a verbal sequence learning task (Hebb Repetition) in young adults with normal hearing. These experimental manipulations enabled us to independently examine the effects of auditory input quality and phonological similarity on verbal sequence learning.

Design: Young adults with normal hearing heard and repeated out loud lists of five consonant-vowel-consonant nonwords under a variety of stimulus conditions. In each condition, a total of 37 lists were presented. Of these, 25 were randomly ordered lists that each appeared only once in the experiment. Interleaved with these random lists was a single repeated list that was presented every third list, for a total of 12 presentations. Sequence learning is assessed by examining then recall accuracy for the repeated list relative to the random lists. Across three experiments (16 participants in each, for a total of 48 participants), we crossed manipulations of auditory input quality (either vocoded or unprocessed) with manipulations of phonological similarity (consonants within each list contained similar or dissimilar phonological features) of nonwords in the repeated and random lists. In vocoded conditions we controlled for identification errors by obtaining verbal labels for each vocoded nonword and scoring recall responses as correct if they matched any of the given verbal labels for the corresponding item.

Results: In experiment 1, we found that participants could recall the repeated list more accurately than the random lists when the repeated list contained phonologically dissimilar consonants, indicating that learning of the repeated list occurred. However, learning was not evident when the repeated list contained phonologically similar consonants (all fricatives). Learning was unaffected by 8 channel vocoding once nonword identification errors were accounted for. Experiment 2 found that mixing a phonologically similar repeated list with phonologically dissimilar random lists did not improve learning. Additionally, a 4-channel vocoder diminished but did not eliminate learning. Experiment 3 replicated the absence of learning for lists of phonologically similar nonwords using lists which contained only stop consonants.

Conclusions: Results indicate that verbal sequence learning of repeated lists was inhibited when the repeated list contains items with similar phonological features. This inhibition of learning occurred

regardless of the specific phonological contents of the list (fricatives vs stops) or of the contents of the interleaved randomly ordered lists. In contrast, learning was evident for vocoded lists despite impaired nonword identification. Taken together, these results indicate that the phonological representation of verbal sequences governs how difficult those sequences are to learn. Thus, verbal learning in children with cochlear implants could be impaired by a lack of phonological feature awareness.

The Digit Triplet Test as an Assessment of Speech Perception

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Objectives: To evaluate the Digit Triplet Test (DTT) for cochlear implant recipients and candidates, as a potential test for remote assessment of clients.

Design: The DTT (two tests), CNC words and phonemes in quiet and BKB-SIN test (two lists) were administered to 20 cochlear implant recipients, 20 cochlear implant candidates with bilateral hearing loss, 20 hearing aid users with mild to moderate hearing loss, and 10 normal hearing listeners. The DTTs were administered free-field with sound booth speakers and through a speaker connected to a laptop. The order of these four DTTs, and the BKB-SIN tests were counterbalanced. The Abbreviated Profile of Hearing Aid Benefit (APHAB), the Hearing Implant Sound Quality Index (HISQUI), and the Nijmegen Cochlear Implant Questionnaire (NCIQ) were used to assess subjective hearing ability. The participant's rated their difficulty completing each test. Analysis: test-retest reliability coefficients, repeated measures ANOVA for learning effect, regression analysis to compare the three speech tests with self-reported hearing ability and best-aided hearing thresholds as the dependent variables.

Results: There was significantly high test reliability for the free-field and laptop-based DTT and the BKB-SIN test ($p<0.001$). There was no significant learning effect for each of these three tests ($p>0.05$).Best ear pure tone average of aided thresholds and APHAB scores were significantly associated with all the speech scores ($p<0.05$). HISQUI9 scores were significantly associated with all the speech scores except CNC phonemes. NCIQ total scores were not significantly associated with any speech scores. With mean scores between 'Easy' and 'Slightly difficult', participants reported significantly less difficulty completing the DTT than the BKB test ($p<0.001$), compared to 'Slightly difficult' to 'Difficult' for the BKB test.

Conclusions: As DDT is associated with objective and subjective hearing ability, it has the potential to be used to assess hearing in a remote setting.

Efferent Activation Improves Intensity Change Detection in Human Listeners

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Objectives: The medial olivocochlear reflex (MOCR) in the brainstem, through inhibition of cochlear amplification, can improve signal detection and discrimination in noise in animals. This finding has been extrapolated to the facilitation of speech perception in noise in humans. However, evidence from human studies on such a direct relationship remains inconclusive. In this study, we investigated the functional role of the MOCR in normal-hearing listeners using simple stimuli, clicks. Specifically, we concurrently

measured the MOCR activity in the cochlea and the N1-P2 acoustic change complex (ACC), while participants performed a behavioral intensity change detection task. We hypothesized that greater activation of the MOCR will be associated with better perceptual detection and greater cortical activation relating to intensity change.

Design: A total of 26 listeners (18-30 years) with clinically normal hearing participated in the study. The intensity increment was imposed on a triad of 'deviant' clicks that occurred at early-, mid-, or late-temporal positions of a click train, while the remaining 'standard' clicks were presented at 75 dB ppSPL (62.5 Hz rate; 0.8-4.8 kHz bandwidth). These temporal positions coincided with null-, partial-, and full-activation of the MOCR. In phase 1, we measured the detection thresholds for intensity increment at the three deviant positions. The detection threshold was defined as the minimum increment in level required to detect the deviant clicks among standard clicks. In phase 2, we assessed the MOCR strength and N1-P2 ACC in response to detecting the deviant clicks in 400 trains (20% with deviants) presented at equal sound pressure levels (SPL) or equal sensation levels (SL, re: individual detection thresholds). The MOCR was estimated by a paradigm previously developed in our lab that allows bilateral evaluation of the time-course of the MOCR strength and concurrent measure of middle-ear muscle reflex using click-evoked OAEs (CEOAEs).

Results: Better detection thresholds were found for deviants at mid- and late-positions than at early positiosn in phase 1. In phase 2, similar significant effects of deviant temporal positions on detection sensitivity (d') were observed in equal SPL conditions but not in SL conditions. The MOCR strength was the strongest at the late-temporal position regardless of SL/SPL conditions. In SL conditions, shorter N1-P2 ACC latencies were found for mid- and late-positions than for the early-position. In addition, the improved detection of deviants at later positions significantly correlated with increased MOCR activation and more efficient cortical detection of the changes, indexed by greater MOCR-induced inhibition in CEOAEs and reduced latency in N1-P2 ACC, respectively.

Conclusions: The significant correlation observed among the detection thresholds, MOCR strength, and N1-P2 ACC latency in our data, suggests a likely involvement of the MOCR in the perceptual and cortical detection of intensity changes in humans. These findings provide the first direct evidence of the assistive role of MOCR in human auditory perception when both perceptual and physiological responses are concurrently measured. These results have implications for the subcortical efferent mechanisms underlying impaired auditory processing in noise and for assistive device technologies aiming to improve speech perception in noise.

A Rapid Measurement for Interaural Mismatch and Interaural Time Differences

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Objectives: Cochlear implant (CI) users often have difficulties utilizing binaural cues such as interaural time differences (ITDs) because of a mismatch in terms of the cochlear stimulation location in each ear. Methods for measuring this mismatch often rely on psychophysical approaches that can require hours of testing. The goal of this study was to evaluate a rapid method for measuring the effects of such mismatches on ITD sensitivity.

Design: Ten normal hearing listeners were tested with a vocoder that simulated current spread. Participants were tested with a traditional adaptive ITD protocol and a rapid descending ITD protocol with fixed ITDs starting at 2000 ¬µs and decreasing in two dB steps to approximately 50 ¬µs. In both protocols, four stimuli were presented. The first and last stimuli always had an ITD of 0 ¬µs. One of the two center stimuli had a non-zero ITD. Participants were to identify which of those had the non-zero ITD. The center frequencies were altered, interaurally, to simulate varying mismatch across ears.

Results: The preliminary results indicated a similar effect of mismatch for both protocols, with considerably shorter testing time for the descending ITD protocol.

Conclusions: The results suggest that the rapid descending ITD protocol is a valid method for assessing the effects of interaural mismatch.

Measures of Social-Environmental Confusion in a Pediatric Pilot Study

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Objectives: CREATE (Cumulative Risks, Early Development, and Emerging Academic Trajectories) is a pilot study designed to develop and validate protocols for measuring chemical and non-chemical stressors in pre-school aged children, with the goal of informing future research aimed at mitigating the effects of cumulative stress on child development and academic readiness. Non-chemical stressors include background noise in the home, which has been identified as an important predictor of overall chaos in the home that can influence neurodevelopment. While previous studies have examined the effect of noise in the home environment, few if any have integrated this into studies of early childhood readiness. We hypothesize that both higher levels of noise and a greater proportion of time spent in noise (vs speech) will be associated with 1) higher ratings of social-environmental confusion on a parent-reported, validated scale and 2) poorer academic readiness.

Design: The CREATE project recruited 20 pre-school aged children and their parents over the course of two years as part of this pilot. Children were recruited from local pre-schools and community centers and participated in two, time-separated study visits. Noise and language exposure (e.g. adult and child word counts, conversational turns) were recorded using the Language Environment Analysis (LENA) system, worn by the children in their home and school environments. Parents or guardians completed the CHAOS (Confusion, Hubbub, and Order Scale) questionnaire, a 15-item parent-report of social-environmental confusion, or chaos. Measures of self-regulation and receptive language were included, as indicators of academic readiness that emerge over the early lifespan through brain development and are highly sensitive to early experiences.

Results: Parents reported a wide range of values for the CHAOS questionnaire (possible range of 15-60) with a mean score of 29.32 (SD 7.11). Ongoing analysis will explore the association between CHAOS scores and environmental noise (as recorded by the LENA system), as well as indicators of academic readiness.

Conclusions: The CREATE pilot study successfully collected personal language and noise exposure data from pre-school aged children. Consideration of both parent-reported chaos in the home and objective measures of noise and language exposures may help identify risk and protective factors in assessments of

academic readiness. Future studies are planned to follow the academic progress of this cohort and further clarify the impact of chemical and non-chemical stressors on academic readiness in young children.