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PODIUM ABSTRACTS

PODIUM SESSION I: ELECTROPHYSIOLOGY AND DIAGNOSTICS

The Audiogram: Hard to Understand and Harder to Improve

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Objectives: To evaluate the efficacy of a patient-centered infographic to supplement the audiogram in improving comprehension of audiological test results. We hypothesized that patient comprehension of audiological test results can be improved by using a patient-centered infographic.

Design: A patient-centered infographic was developed through an iterative design process with input from patient focus groups. Comprehensibility of test results presented in the new infographic was compared against a conventional audiogram in 165 cognitively normal older adults who were randomly assigned to either the audiogram or the infographic. Health literacy was measured in all participants using the Newest Vital Sign.

Results: Mean comprehension on a 10-point test for the conventional audiogram was 5.8 with a trend of poorer comprehension in those with limited health literacy. Comprehension for the new infographic was similar with a mean score of 5.7/10 and with a similar influence of health literacy. Variability of comprehension scores was greatest for those with limited health literacy for both groups.

Conclusions: The changing hearing healthcare landscape demands a readily comprehensible communication tool for patients and consumers. The audiogram is difficult to comprehend for patients, especially for those with limited health literacy. However, initial attempts to create a patient-centered infographic to supplement the audiogram were not any more successful in conveying comprehensible test results. Further refinement of the infographic using principles of patient-centered design is necessary. We believe this can be achieved once patient needs expressed in focus groups are effectively incorporated into the design.

Using the Audiogram to Identify Hearing Loss in Children

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Objectives: Examining electronic medical records with "big data" analytics provides a unique opportunity to determine the current state of diagnostic practice in pediatric hearing health care. Of particular interest is to identify gaps in care for children with developmental disabilities as the current methods for obtaining an audiogram - the "gold standard" of clinical care - are not well-suited for children with diverse or complex developmental profiles. As a first step, it is critical to determine a standard method for identifying children with hearing loss. The purpose of this study was to compare different methods for identifying hearing loss based on pure-tone thresholds and to determine the effectiveness of these methods based on child age and disability status.

Design: We examined audiogram and diagnosis data from 133,664 children (0-18 years; 360,301 encounters) that received care at Children's Hospital of Philadelphia, Vanderbilt University Medical Center, or Boston Children's Hospital. 10,538 children were classified as having a developmental disability: a diagnosis of autism spectrum disorder, Down syndrome, intellectual disability, or cerebral palsy. For each encounter, hearing status was classified (i.e., insufficient data, normal hearing, or hearing loss) based on thresholds at 500, 1000, 2000, and 4000 Hz. Six methods were used that varied based on the number of thresholds required; elevated single threshold or pure-tone average; and if data were obtained in a single or multiple visits. For each method, hearing loss was classified with a conservative or liberal criterion (>25 or >15 dB HL). The stability of the hearing classification over time was examined.

Results: Across the methods that required multiple thresholds, hearing status could not be determined for 14 to 37% of encounters because of insufficient data. High rates of insufficient data were seen for children under 4 years and for children with developmental disabilities. The proportion of encounters classified as "hearing loss" varied across methods, with the highest rate being for methods that required a single threshold to be elevated. A liberal criterion resulted in a higher rate of classifying hearing loss than a conservative criterion by a factor of 1.3 to 1.6 depending on the method. There was no benefit of allowing thresholds to build up over multiple test sessions to determine hearing status.The average child age when hearing status was classified for the first time depended on the method, ranging from 5.3 to 7.1 years. Compared to children not flagged with a developmental disability, children with developmental disabilities were more likely to have their hearing status determined at older ages, to have hearing loss, and to have a stable classification over time.

Conclusions: Results from this study reveal several differences between methods for classifying hearing status based on the audiogram. These findings also highlight the need for additional research examining disparities in clinical care for children with developmental disabilities.

Detection of Slight-Mild Hearing Levels with DPOAE and Wideband Tympanometry

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Objectives: Even slight-mild congenital hearing loss can affect speech-language development and academic progress, but newborn screening and current diagnostic criteria are relatively insensitive to hearing levels below 40 dB HL. Slight hearing loss may be more likely to be conductive in origin, making it more difficult to determine what type of intervention is needed. This study was designed to assess whether distortion product otoacoustic emissions (DPOAE) using age appropriate norms are sensitive and specific for detection of all degrees of educationally significant hearing loss (>15 dB HL). In addition, wideband tympanometry was employed to assess presence of middle ear dysfunction in relation to degree of hearing loss and DPOAE results.

Design: Prospective case control study, randomized for test order with auditory brainstem responses (ABR) and auditory steady state responses (ASSR) using narrowband chirps (500, 100, 2000 and 4000 Hz) as the "gold standard" for diagnosis of hearing loss. Infants and children (n=102; 1 to 80 months of age) who failed newborn screening or had suspicion of hearing loss were seen in outpatient or surgical units for diagnostic audiology assessments. After informed consent and completion of IRB approved parent permission, children were assessed with threshold ABR and ASSR in randomized order. They also were tested with DPOAE (six f2 frequencies between 2000-8000 Hz), pure tone tympanometry (1000 Hz for age< 6 mo. and 226 for age >6 mo.) and wideband tympanometry on the same day in both ears.

Results: A total of 165 ears were assessed with ABR, ASSR, tympanometry and DPOAE. Hearing level was classified as normal=94 (57%), slight=13 (8%), mild=23 (14%), moderate=12 (7%), and severe to profound=21 (13%). One case of possible auditory neuropathy was excluded (absent ABR and ASSR, normal DPOAE). Using recently published normative levels for infants, DPOAE had overall sensitivity of 96% and specificity of 81% for detection of slight or greater hearing level. Within the slight category, sensitivity was 70%, while it was 100% for mild and greater hearing levels. Area under the receiver-operator curve (AUC) was .88 to .95, depending on the DPOAE f2 frequency. For ears with normal hearing, wideband middle ear assessment was normal for 84% of ears. For ears with hearing loss, 55% had abnormal middle ear testing. Abnormal middle ear function was more frequent among the slight-mild categories than for moderate and greater categories.

Conclusions: Using age-appropriate levels, DPOAE assessment is highly sensitive and specific for diagnosis of slight or greater hearing loss. In infants and children being assessed for possible hearing loss, abnormal middle ear function is prevalent and thus requires assessment using tympanometry and bone conduction ABR or ASSR. More research is needed that compares OAE and wideband tympanometry measures with bone conduction ABR and ASSR thresholds.

Development of a Gene Therapy for Otoferlin-Deficient Auditory Neuropathy

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Objectives: Otoferlin deficiency secondary to biallelic mutations of the OTOF gene causes permanent congenital auditory neuropathy deafness. Otoferlin is expressed in the primary sensory receptors of the ear (the inner hair cells) and enables synaptic transmission between the inner hair cells and the dendrites of the auditory nerve by functioning as a calcium sensor for exocytosis during synaptic vesicle release, vesicle trafficking, and replenishment. Of the 1 in 500 neonates who are born with hearing loss annually in the US, 50 to 200 are caused by Otoferlin deficiency.There are no approved therapies for Otoferlin deficiency; infants with biallelic OTOF mutations are currently managed with assistive devices.

Design: We have developed an Adeno-Associated Virus (AAV)-based gene transfer therapy for rescue of hearing in an Otoferlin deficiency model that mimics a common human OTOF mutation (OTOFQ828X/Q828X). Because human OTOF cDNA exceeds the packaging capacity of a standard AAV, we used a dual AAV system to locally deliver Otoferlin to the inner ears of OTOFQ828X/Q828X mice. Key considerations for vector development included the human OTOF isoform that should be expressed, the promoter sequence that determines in which cells the human OTOF will and will not be expressed, the recombinogenic region that enables the dual AAV system, and the capsid in which these elements are packaged for efficient delivery into the target cells.

Results: Using a local dual AAV delivery of hOTOF, pharmacological modulation of Otoferlin expression and durable functional rescue as measured by the Auditory Brainstem Response were demonstrated in the OTOFQ828X/Q828X mice with dosing in mature ears. Safety of efficacious dosing with dual AAV delivery of hOTOF under the control of a hair cell-specific promoter was demonstrated in OTOFQ828X/Q828X, OTOFQ828X/wt, and OTOFwt/wt mice. Comparison vectors that did not include an engineered promoter to

restrict transgene expression to target cells resulted in dose-limiting toxicity, a finding consistent with recent observations for retinal gene therapies and a critical consideration for translation to the clinic. Thus, we selected a synthetic cell-specific promoter to bring forward for therapeutic development. In order to advance DB-OTO (dual AAV Delivery of human OTOF with a cell-specific promoter) to the clinic for children with severe-profound SNHL due to biallelic OTOF mutations, we developed a surgical delivery approach that could be translated into routine otolaryngological practice. This approach involves slow AAV infusion through the RW membrane alongside vestibular fenestration for egress of displaced perilymph by the investigational product. Exploratory studies in non-human primate and human temporal bones suggest the feasibility of this approach for clinical translation.

Conclusions: DB-OTO is a promising emerging therapeutic for genetic hearing loss, and has the potential to provide the first clinical proof-of-concept for gene therapy in the inner ear.

The Envelope Following Response in Young Veterans: Evidence for Synaptopathy
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Objectives: Although several non-invasive physiological measures appear to be sensitive to cochlear synaptopathy in animal models, including auditory brainstem response (ABR) wave I amplitude, the middle ear muscle reflex (MEMR), and the envelope following response (EFR), human studies of these measures in samples that are expected to vary in terms of the degree of noise-induced synaptopathy have resulted in mixed findings. One explanation for the differing results may be differences in the type of noise exposure across studies. For example, the synaptopathy risk for recreational noise exposures such as concerts, night clubs, and bars may be much lower than the synaptopathy risk for military noise exposures such as firearms, artillery, and explosions. We previously demonstrated that young Veterans reporting high noise exposure during their military service show a reduction in ABR wave I amplitude and MEMR strength compared to non-Veterans who have never used a firearm, consistent with animal models of noise-induced synaptopathy. We have also showed that Veterans with tinnitus have lower ABR wave I amplitudes than non-Veteran controls and Veterans without tinnitus. In this study, we measured the EFR, ABR wave I amplitude, and MEMR in a sample of young Veterans and non-Veterans with clinically normal audiograms. Our hypothesis was that Veterans with high levels of self-reported noise exposure and Veterans with tinnitus would have reduced EFR magnitudes and that ABR wave I amplitude and MEMR strength would be correlated with EFR magnitude.

Design: EFRs in response to a 4 kHz carrier tone modulated at 110 Hz were measured in a sample of 79 young military Veterans and non-Veterans with normal audiograms and robust DPOAEs. ABRs were measured in response to a 100 dB peSPL 4 kHz toneburst. Wideband MEMRs were measured for a contralateral broadband noise elicitor. Self-reported noise exposure was assessed using the Lifetime Exposure to Noise and Solvents Questionnaire (LENS-Q). Study participants also completed a questionnaire that asked if they experienced frequent or constant tinnitus.

Results: Mean EFR magnitude was lower for Veterans compared with non-Veteran controls, the perception of tinnitus was associated with lower EFR magnitudes, and the magnitude of the EFR was positively correlated with ABR wave I amplitude and MEMR strength.

Conclusions: The relationship between Veteran status and EFR magnitude in the context of a normal audiogram is consistent with animal models of noise-induced cochlear synaptopathy. This suggests that EFR measurements may be informative in human studies of synaptopathy. Positive relationships between EFR magnitude and both ABR wave I amplitude and MEMR strength in this sample suggest that these three measurements are providing

similar information about synaptic/neuronal function in humans. In addition, the observed reduction in EFR magnitude among Veterans reporting tinnitus confirms previous findings and adds support to the hypothesis that some forms of tinnitus may be a perceptual consequence of cochlear synaptopathy.

Predicting Human Synapse Counts From Physiological Measurements Using Computational Models

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Objectives: Approximately 40% of human cochlear synapses are lost by 50 years of age. Cochlear synaptopathy is predicted to result in perceptual deficits including tinnitus, hyperacusis, and difficulty understanding speech-in-noise. However, there is currently no method for diagnosing synaptopathy in living humans. Without a means of diagnosing synaptopathy, we cannot conclusively determine if noise-induced synaptopathy occurs in humans, identify the perceptual consequences of synaptopathy, or test potential drug treatments. The auditory brainstem response (ABR) wave I amplitude is a non-invasive physiological measure shown to be sensitive to synaptopathy in animal models. However, wave I amplitude alone is insufficient to detect synaptopathy in individual human subjects. This is, in part, due to the likelihood of outer hair cell (OHC) damage co-existing with synaptopathy in humans with sensorineural hearing loss. An existing computational model of the auditory periphery (CMAP; Verhulst et al. 2018) can predict distortion product otoacoustic emissions (DPOAEs) and ABRs for any combination of OHC and synaptic loss. In this study, Bayesian regression analysis was used to fit the CMAP, generating synapse predictions for individual human subjects based on their measured DPOAE and ABR wave I amplitude measurements. Synapse predictions were then evaluated for relationships with synaptopathy risk factors (noise exposure) and expected perceptual consequences of synaptopathy (tinnitus and difficulty with speech-in-noise perception). The hypothesis was that biologically plausible synapse predictions could be generated for each human subject and that lower predicted synapse counts would be associated with higher noise exposure history, increased likelihood of tinnitus, and poorer speech-in-noise perception.

Design: Synapse counts were predicted from measured ABR and DPOAE data for individual subjects in a sample of 74 young military Veterans and non-Veterans with normal audiograms. The model was fit in two stages. First, a machine learning approach was used to adjust cochlear tuning given measured DPOAEs, thereby creating a DPOAE-adjusted CMAP for each subject. Simulated DPOAEs generated using the DPOAE-adjusted CMAPs closely matched measured DPOAEs. Second, the DPOAE-adjusted CMAP for each subject was used to generate simulated ABR responses to 3, 4, and 6 kHz toneburst stimuli for low, medium and high spontaneous rate auditory nerve fibers (ANFs) distributed uniformly along the tonotopic axis of the human cochlea. The average number of ANFs per IHC along the length of the cochlea (i.e., a synaptogram) was modeled as a parabola with priors for the coefficients derived from human temporal bone synapse counts (Wu et al. 2019).

Results: Predicted synapse counts show the expected relationships with synaptopathy risk factors and predicted perceptual consequences. Groups with higher noise exposure histories had lower predicted synapse counts than controls. Report of tinnitus was also associated with lower synapse counts. In addition, lower predicted synapse counts are weakly correlated with poorer speech-in-noise perception.

Conclusions: These results illustrate the feasibility of this modeling approach and demonstrate the utility of a model that reduces multiple sources of information, including DPOAEs and ABRs measured at multiple levels and frequencies, into a single synaptogram. This work was supported by VA RR&D C1484-M/C2104-W/C9230-C, NIDCD R21 DC01696, and ERC 678120.

PODIUM SESSION II: COGNITION AND PSYCHOACOUSTICS

Cognitive Function and Hearing Aids: Can We Delay Cognitive Decline?

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Objectives: Hearing loss has been identified as a modifiable risk factor for dementia, making the largest single contribution to the identified potentially modifiable risk factors. However, whether treatment of hearing loss can delay the onset of cognitive decline is currently unknown. This ongoing study aims to investigate the effects of hearing aid use on cognitive decline and other quality of life outcomes in older adults with hearing loss. It was hypothesized that hearing aid use may delay cognitive decline.

Design: In this longitudinal multiple cohort study, participants aged 60 years and over (mean age 71 yrs; n = 101) with hearing loss were recruited from attendees of the University of Melbourne audiology clinic who were eligible for hearing aid fitting and who had not previously used these. They were assessed before and at 18-month intervals after hearing aid fitting on hearing, cognitive function, speech perception, quality of life, physical activity, loneliness, social isolation, mood, physical health, genetic risk. After fitting, device use and benefits were also objectively measured. Study group outcomes were compared with those of "control" participants in a national study of aging who had both normal hearing and hearing loss, and who underwent the same assessment protocol.

Results: At baseline, multiple linear regression showed hearing loss and age predicted significantly poorer executive function performance. Tertiary education predicted significantly higher executive function and visual learning performance. Retirement predicted poorer psychomotor function and visual learning.18 months after hearing aid fitting, speech perception in quiet, self-reported listening disability and quality of life had significantly improved. Group mean scores across the cognitive test battery showed no significant decline, and executive function significantly improved for both sexes, as did working memory for males. Reliable Change Index scores also showed either clinically significant improvement or stability in executive function for 95.5% of participants, and for females for working memory, visual attention and visual learning. Cognitive changes varied according to amount of device use. Differences in device use and cognitive outcomes at 18 months between males and females were observed.Performance for the comparative "control" group showed no significant change over the 18 mth period across the cognitive battery. Updated 18-month data for a larger sample will be discussed, along with the first presentation of 36-month follow-up data currently being collected.

Conclusions: Participants showed relative stability and even significant improvement in cognition after 18 months of hearing aid use, suggesting that treatment of hearing loss with hearing aids may delay cognitive decline. However, further recruitment and follow-up is required to document the effects of hearing aid use on cognition over time in a larger sample.This study will provide rigorous evidence of the effects of hearing aid use on cognition in older adults over time. This evidence can be used in counselling adults with hearing loss regarding treatment of hearing loss. Differences in device use and cognitive outcomes between males and females were observed, and these may have implications for treatment and management. Further follow-up to document the trajectory of treatment effects on cognition is ongoing.

Brain Resting State Functional Connectivity and Age-Related Hearing Loss

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Objectives: The objective was to examine associations between intra-network functional connectivity measured using resting state functional magnetic resonance imaging (rsfMRI) and age-related hearing loss.

Design: This investigation was a cross-sectional analysis of an ongoing prospective cohort study. The analysis included a community-based cohort of 73 late middle-aged adults without dementia who underwent audiometry and rsfMRI from 2016-2020. Hearing thresholds were averaged to calculate the pure-tone average (PTA) for each ear. PTA in the better ear served as the measure of hearing. Functional connectivity was estimated as temporal correlations among a set of 53 putative functional regions defining nine networks that cover the brain's better known functional networks: auditory, cingulo-opercular, default mode, dorsal attention, frontoparietal control, salience, somatomotor, ventral attention, and visual network. The average inter-nodal correlation within each network provided an estimate of intra-network functional connectivity. Linear regression was performed to analyze the association between resting state functional connectivity and a 10 dB worsening in hearing. Models were adjusted for age, gender, years of education, and hearing aid use.

Results: Mean age was 64.6 ($\pm$ 3.7) years. Mean PTA in the better ear was 21.2 ($\pm$ 9.0) dB. Univariate regressions demonstrated that a 10 dB worsening in hearing was associated with higher intra-network connectivity within the frontoparietal control network (estimate=0.073, p=0.04). Adjusting for covariates, a 10 dB worsening in hearing was associated with lower intra-network connectivity within the visual network (estimate=-0.181, p=0.03). A near-significant relationship was also observed between hearing and higher frontoparietal control network connectivity in the adjusted model (estimate=0.072, p=0.08).

Conclusions: Age-related hearing loss may be associated with a less coherent visual network due to audiovisual cross-modal reorganization, in which visual processing maps onto cortical areas normally used for auditory processing. Conversely, hearing loss may be associated with a more coherent frontoparietal control network due to increased listening effort requiring increased top-down attentional control. These findings add to growing evidence that age-related hearing loss is associated with neuroplastic changes in the brain. Future research should confirm these results in a larger sample and longitudinally study how functional networks change as hearing loss progresses.

Psychological Well-Being is Associated with Hearing Functions in Middle-Aged Adults

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Objectives: Age-related hearing loss is a common disabling condition and a major health concern in aging populations for which we are still lacking effective treatment and prevention methods. Initial age-related changes in hearing function start early in midlife and can be a result of degeneration in peripheral and central components of the auditory system. Identifying potential modifiable risk factors early in life has great potential for early intervention. In the search for protective factors of age-related diseases, psychological well-being has gained growing interest. Psychological factors of well-being have been associated with better health including vascular, inflammatory and metabolic factors and cognitive function. Importantly, psychological well-being is considered modifiable and can be enhanced (e.g. through counseling and education) underscoring its potential for prevention and intervention methods to support healthy aging. However, its association with hearing is not well understood. Therefore, we aimed to determine the association of psychological well-being and hearing in a cohort of middle-aged adults.

Design: This cross-sectional study included 1944 Beaver Dam Offspring Study participants (aged 27-89 years, mean 58; 55% were women), who participated in the 10-year examination. We assessed psychological well-being using the Ryff Psychological Well-Being questionnaire subscales for Positive Relations with Others and Purpose in Life and combined them in a summary score. Hearing sensitivity was assessed through air-conduction pure-tone audiometry (PTA, averaged thresholds of 0.5, 1, 2 and 4 kHz; impairment defined as PTA>25dB HL in the worse ear) and speech perception using the word recognition in competing message Northwestern University Auditory Test Number 6 in the better ear and dichotic digits free recall test. Multivariable linear and logistic regression and generalized estimating equation models were used to determine associations of the determinant psychological well-being with the four different hearing outcomes. Models were first adjusted for age, sex and education and then further adjusted for chronic health conditions (ever heavy alcohol consumption, diabetes, cardiovascular disease, long-term elevated inflammation) and health behaviors (smoking, exercise, waist circumference).

Results: Higher psychological well-being was associated with better hearing sensitivity (-1.00 dB HL decrease per 1 SD increase in psychological well-being; 95% confidence interval (CI) -0.40,-1.61; p=.001) and dichotic digits performance (1.02% increase per 1 SD increase in psychological well-being; 95% CI 0.52,1.53; p<.0001). These effect sizes were comparable to 1.5 years and 3.5 years of aging, respectively. Effect sizes marginally changed with further adjustment. Moreover, individuals with higher psychological well-being had a reduced odds for hearing loss (odds ratio OR=0.88 per 1 SD increase in psychological well-being; 95% CI 0.79,0.98; p=0.02). Psychological well-being did not show an association with word recognition in competing message.

Conclusions: Better psychological well-being was associated with better hearing and a reduced risk of hearing impairment in midlife. This effect remained true when adjusting for education and various chronic health conditions and behavioral factors, indicating that the association might be unrelated to differences in socio-economic or health status. Future studies should determine potential mechanisms underlying this association. If confirmed, these findings could have important implications for developing hearing intervention and prevention strategies.

The Longitudinal Association of Subclinical Hearing Loss with Cognition

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Objectives: An independent association has been observed between age-related hearing loss and cognition. However, few studies have investigated whether the association exists among those with subclinical hearing loss, defined as ≤25 dB, i.e., hearing loss below the threshold for which hearing aids are typically recommended. Our objective was to examine the longitudinal association between subclinical hearing loss and neurocognitive performance. As a reference, we also examine the longitudinal association among those with all ranges of hearing.

Design: A longitudinal analysis was conducted among 2115 subjects who underwent audiometric testing in a US multi-centered epidemiologic cohort study (Health, Aging, and Body Composition [Health ABC], a biracial cohort [white and black] of well-functioning adults aged 70–79 years). The primary exposure was hearing in the better ear, as determined by the average threshold for pure tone frequencies 500, 1000, 2000, and 4000 Hz. Subclinical hearing loss was defined as hearing ≤25 dB. Audiometry was conducted at year 5. The primary outcome was neurocognitive performance, measured by the Digit Symbol Substitution Test (DSST, a speed/attention test), Modified Mini Mental State Examination (3MS, a global cognitive function test), and the CLOX1 (an executive function clock drawing test). Higher scores indicated better neurocognitive performance. Linear mixed models were performed to assess the longitudinal association between hearing and cognitive performance, adjusting for potential confounders (age, gender, race, education, smoking status, hypertension, diabetes, stroke, and hearing aid use). The interaction between hearing and year was included in the model to allow the association between hearing and cognitive performance to vary across time. Models were fit first among all individuals and then among individuals with subclinical hearing loss only.

Results: Among 2115 individuals, mean (SD) age was 73.5 (2.9) years; 1105 (52.3%) were women. Mean (SD) pure-tone average of the better ear was 30.0 (13.1) dB. Follow-up ranged from 3 to 16 years (mean = 9.1 years). Among all participants, worse hearing was associated with a significantly steeper decline in cognitive performance as measured by the DSST (0.054-point/year steeper decrease per 10 dB worse hearing, 95% confidence interval [CI]: 0.026-0.082) and 3MS (0.043-point/year steeper decrease per 10 dB worse hearing, CI: 0.025-0.062), but not CLOX1. Among those with subclinical hearing loss (,â§25 dB), worse hearing was associated with a significantly steeper decline in cognitive performance as measured by DSST (0.120-point/year steeper decrease per 10 dB worse hearing, CI: 0.013-0.228) and 3MS (0.063-point/year steeper decrease per 10 dB worse hearing, CI: 0.003-0.130), but not CLOX1.

Conclusions: Among those with subclinical hearing loss, worse hearing was associated with steeper declines in cognitive performance over time. The relationship between hearing loss and cognition may begin at earlier levels of hearing loss than previously recognized.

Effects of Rate, Age, Hearing loss and Cognition on Discourse Comprehension

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Objectives: Real world conversations unfold quickly, and the ability to process rapid speech is essential to successful participation in meaningful communication. Discourse comprehension requires listeners to interpret the meaning of an incoming message, integrate the message into memory and use the information to respond appropriately. The ability to perform this series of events declines when speech is presented rapidly, especially for older adults. There are conflicting hypotheses regarding the reason for rate-induced comprehension difficulties. The overall goal of this study was to determine the relative impact of multiple factors on discourse comprehension performance for younger normal-hearing adults and older adults with and without hearing loss using a clinically feasible testing approach.

Design: Listeners were required to self-select a time-compression ratio where they could understand and effectively answer questions about spoken discourse comprehension passages. Based on previous work, the self-selection method in the current study was expected to produce a fixed level of comprehension accuracy performance (i.e. near 80% correct) across a wide range of time-compression ratios. Therefore, the variable of interest is the time-compression ratio that yields the equivalent percent correct comprehension performance. Comprehension passages were presented under two speech presentation rate conditions (silences intact or silences removed). The silences intact condition represented the overall information rate of the signal. The silences removed condition represented the articulation rate of the signal. Participants were also assessed on multiple cognitive measures, including the Trail Making task (processing speed), the Reading-SPAN (working memory) and the Flanker task (attention/inhibition).

Results: Results showed that older adults with and without hearing loss required a slower time-compression ratio in both conditions to reach 80% performance for comprehension accuracy compared to younger listeners. In addition, older hearing-impaired listeners selected slower time-compression ratios compared to older normal hearing listeners. The results also showed that self-selected time-compression ratio was faster in the silences intact condition compared to the silences removed condition. The presence of silences allowed listeners in all groups to select a faster time-compression ratio, but older participants with hearing loss showed the largest effect. The results also indicated that processing speed and working memory capacity were significant predictors of self-selected time-compression ratios across all groups and both speech presentation rate conditions.

Conclusions: Listeners in both older groups were more adversely affected by rapid speech than younger listeners during a discourse comprehension task. Furthermore, hearing loss, in addition to age, affected the rate required by listeners to comprehend a spoken passage. The results also indicated that self-adjusted rate is modulated by available processing time or the information rate of the signal, rather than the articulation rate, especially for older adults with hearing loss. This result may suggest that the older hearing-impaired group relied more on the perception of overall information rate compared to the two normal hearing groups. Lastly, speed of processing and working memory capacity are involved in the processing of rapid speech during a discourse comprehension task for younger adults and older adults with and without hearing loss.

Association of Hearing Loss With Neuropsychiatric Symptoms in Older Adults

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Objectives: This study investigated the association between hearing loss and NPS among community- dwelling patients from a tertiary memory care center.

Design: Participants of this cross-sectional study were patients followed at the Johns Hopkins Memory and Alzheimer's Treatment Center who underwent audiometric testing during routine clinical practice between October 2014 and January 2017.

Results: Participants (n = 101) were on average 76 years old, mostly female and white, and had a mean Mini-Mental State Examination score of 23. We observed a positive association between audiometric hearing loss and the number of NPS (b = 0.7 per 10 dB; 95% confidence interval [CI]: 0.2, 1.1; t = 2.86; p = 0.01; df = 85), NPS severity (b = 1.3 per 10 dB; 95% CI: 0.4, 2.5; t = 2.13; p = 0.04; df = 80), and depressive symptom severity (b = 1.5 per 10 dB; 95% CI: 0.4, 2.5; t = 2.83; p = 0.01; df = 89) after adjustment for demographic and clinical characteristics. Additionally, the use of hearing aids was inversely associated with the number of NPS (b = −2.09; 95% CI −3.44, −0.75; t = −3.10; p = 0.003; df = 85), NPS severity (b = −3.82; 95% CI −7.19, −0.45; t = −2.26; p = 0.03; df = 80), and depressive symptom severity (b = −2.94; 95% CI: −5.93, 0.06; t = 1.70; p = 0.05; df = 89).

Conclusions: Among patients at a memory clinic, increasing severity of hearing loss was associated with a greater number of NPS, more severe NPS, and more severe depressive symptoms, while hearing aid use was associated with fewer NPS, lower severity, and less severe depressive symptoms. Identifying and addressing hearing loss may be a promising, low-risk, non-pharmacological intervention in preventing and treating NPS.

Preliminary Pupillometry Experiences in Measuring Listening Effort in Younger and Older Listeners
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Objectives: Audiologists are increasingly interested in measuring listening effort in individuals with Sensorineural Hearing Loss (SNHL) and the possible effects of hearing aid technologies in reducing this effect. Many older individuals with SNHL report that listening makes them exhausted easily, making them avoid necessary social interactions, and this leaves them feeling even more isolated, lonely, and fatigued.Listening effort incorporates use of multiple auditory perceptual and mental processes, including vigilance, working memory, linguistic cues, and cognitive control. Older individuals must possess not only sufficient mental

resources in challenging listening tasks but should also be willing and be able to allocate available resources efficiently to meet the demands. Degraded acoustic (bottom-up) signal associated with aging and SNHL is likely to force recruitment of more cognitive (top-bottom) resources in older listeners with potential of poorer outcomes on speech intelligibility and working memory tasks.Currently listening effort is measured by three main methods: a) Subjective survey measures, b) Behavioral accuracy and reaction time measures, and c) Physiological measures. Pupillometry provides an objective physiological measure that will assist audiologists in their pursuit of listening effort. Pupillometry provides at least four main advantages for audiologists. Firstly, it can measure changes in pupil dilation by an eye tracker that may already be available on a clinical videonystagmography goggles system. Secondly, changes in speech intelligibility can be correlated with changes in pupil dilation on listening tasks providing potential benefits of amplification benefit. Thirdly, an objective response is offered because the pupillary response is not under volitional control and reflects activity of the locus coeruleus (LC) brainstem nucleus that drives shifts in arousal and attention. Finally, pupillometry can provide objective measures of listening effort that vary with increasing auditory and cognitive demands.

Design: We measured pupillometry responses in younger and older listeners using a commercially available Micromedical videonystagmography VisualEyes goggles system in the current study. Three types of tasks were used for study purposes in younger and older listeners: 1) Working memory (WARRM), 2) Speech in Noise (QuickSIN), and 3) Time Compressed Speech (TCS). The working memory measure called Word Auditory Recognition and Recall Measure (WARRM) is a standardized measure that demands recognition, classification, and recall during speech intelligibility tasks. The speech intelligibility in noise measure (QuickSIN) requires speech intelligibility under 6 different Signal to Noise Ratios (SNRs). The ratio of time-compression is the percent reduction in the overall signal duration with respect to the original signal. In our study, each participant will be presented with 50 words presented at 0% TCS (uncompressed), 30% TCS (words compressed to 30% of their original duration), and 60% TCS (words compressed to 60% of their original duration).

Results: Results from the preliminary studies show that all three listening tasks described above impact pupil dilation in various conditions. Age and working memory load had statistically significant on pupil dilation, and difficult SNR/TCS conditions impacted younger listeners on pupillometry tasks.

Conclusions: Results of the current study indicate that acoustic, linguistic, and cognitive demands impact effortful listening measured by pupillometry.

PODIUM SESSION III: HEARING AIDS AND IMPLANTS

Investigating the Encoding of Indexical Properties by Cochlear Implant Processors
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Objectives: Listeners typically extract considerable information from the signal they receive when listening to other speakers. In addition to the message being conveyed, listeners are able to detect many characteristics about the speaker, such as age and gender, and if it is a familiar speaker, they are able to recognize their voice. However, cochlear implant (CI) processors greatly distort spectrally complex signals such as voices, creating considerable difficulties for perceiving these indexical properties. The goal of this study is to determine how indexical properties of speech are encoded by the CI processor.

Design: Twenty-four people were recorded producing a sustained /a/ five times. These recordings were played back to a CI processor programmed with a default clinical map. The processor was connected to a CI-in-a-box

and an electrodogram was recorded for each sample. Two sets of comparisons were made. The first comparison involved two samples, where each came from a different individual. The second comparison involved two samples, both from the same individual. In both cases, the compared samples had similar F0s.

Results: Preliminary results indicated that there was little similarity between the pattern of stimulation intensities across electrodes when comparing stimuli from two different individuals. In contrast, multiple stimuli from the same individual yielded similar patterns of stimulation intensity across electrodes.

Conclusions: These results suggest that indexical properties are preserved to some extent by the patterns in stimulation intensity across electrodes.

Novel Strategy for Enhancing Cochlear Implant-Mediated Delivery of Low Frequencies
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Objectives: Cochlear implant (CI) users frequently demonstrate limited ability to perceive low frequency sound information, due to both reduced stimulation of the apical cochlea and high-pass filtering of the low end frequency spectrum by current CI sound processor designs. This limitation in low frequency perception has significant implications for perception of complex signals such as speech and music, particularly with regards to complex pitch. The aim of this project was to utilize a novel modification of a CIS-based cochlear implant processing strategy to provide greater low frequency information for CI users.

Design: We used a novel approach to provide low frequency enhancement of currently existing CIS algorithms (LFE-CIS). For this approach, a new "pseudo-channel", which only includes frequencies below 100 Hz, was added to the existing CIS channels. In LFE-CIS, the energy of each existing CIS low frequency channel was summed with and/or modulated by the pseudo-channel energy in a graded fashion with greatest enhancement in the apical-most channel and decreasing amounts in successively more basal channels.

Results: We performed a theoretical analysis of the electric field patterns in the cochlea created by LFE-CIS and showed an increase in the low frequency information in the apical region of the cochlea. Using a custom in-house designed cochlear implant sound processor interface, we implemented the LFE-CIS strategy in a cochlear implant user (first author, MM). We then demonstrated improvement of this CI user to perceive reductions in low frequency musical information using a bass-frequency CI-MUSHRA paradigm when using LFE-CIS in comparison to standard CIS.

Conclusions: Enhancement of low frequency information provided by a cochlear implant may be possible through the use of modulation of apical channels by a pseudo-channel containing only low frequency information. This approach (LFE-CIS) requires further investigation and validation to assess the potential benefits for CI users.

Extended High-frequency Hearing Impairment: Relation to Routine Earphone Use, Signs of Early Aging, Speech-in-Noise Perception, Cochlear Function, and Other Risk Factors
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Objectives: Humans can hear up to 20 kHz. Some evidence suggests that hearing impairment in the extended high frequencies (EHFs; >9 kHz) is associated with poor speech-in-noise recognition despite normal audiogram (0.25- 8 kHz). The overall goal of the present study was to elucidate the relationship between EHF hearing impairment and speech-in-noise recognition in listeners with a normal audiogram. Specifically, we aimed to:1.Characterize the EHF hearing impairment and identify potential risk factors, such as routine earphone use (a form of noise exposure).2.Determine the effect of EHF impairment on speech-in-noise recognition after controlling for standard frequency thresholds and age.3.Examine the extent to which EHF hearing and cochlear functioning in the standard frequencies are related.

Design: Hearing thresholds at standard and EHFs (10, 12.5, 14 and 16 kHz), speech recognition thresholds (SRTs) using digit-triplets in speech-babble and clinical distortion-product otoacoustic emissions (DPOAEs; f2 frequency= 2, 3, 4 and 5 kHz) were measured from both ears in 222 listeners (19-38 years) with a normal audiogram (≤ 20 dB HL at standard frequencies). Linear mixed models were applied to analyze the relationship between age, EHF thresholds, and SRTs.

Results: Twenty-eight and 14 participants (out of 222) had bilateral and unilateral EHF hearing impairment, respectively. Among all EHFs, thresholds for 16 kHz was most frequently elevated. The mean age of the EHF-impaired group was significantly higher than the normal-hearing group (NH: mean= 24.19 years, EHF-impaired: mean= 28.88 years). Only seven out of 222 participants had significant case history and/or listening-in-noise complaints; occupational noise exposure was the risk factor in three participants; two of these participants with worse EHF thresholds also complained of hearing difficulties in noisy backgrounds and had absent DPOAEs in at least one frequency.

Conclusions: An important finding is that, on average, by the age of 30 years, listeners may develop hearing impairment for the extended high frequencies. Detailed results demonstrate the complex interrelationships between EHF hearing impairment and speech-in-noise recognition in young adults with a normal audiogram. Results from this study further highlight the clinical utility of measuring hearing at extended high frequencies.

Health Literacy and Hearing Device Use Outcomes for Older Adults
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Objectives: Hearing loss is the third most common chronic condition in older adults, with the most effective remediation being hearing aid (HA) amplification. Despite the significant health burden of untreated hearing loss, fewer than 30% of people who would benefit from HAs use them, due in part to poor accessibility and high cost. In an effort to increase accessibility and affordability of hearing healthcare, policy makers have created a category of over-the-counter (OTC) HAs under FDA regulations to be in place by 2020. Low-cost OTC HAs, or direct to consumer devices, are viable options to increase use of amplification when cost is inhibitory. However, only 12% of adults can effectively obtain, process, read, and understand healthcare information. Therefore, low health literacy can undermine the potential efficacy of an OTC delivery model. To date, there is a lack of evidence exploring how health literacy may impact clinical outcomes of hearing device use. We hypothesized that older adults with low health literacy would have poor clinical outcomes. The purpose of the study was to investigate the relationship between health literacy and hearing-related outcomes of direct-to-consumer hearing device use.

Design: This was a prospective cohort study. We recruited twenty-seven older adults with mild-to-moderate sensorineural hearing loss (mean age = 69.4 yr; Range: 60-82 yr) from the local community via word of mouth and flyers. None were hearing aid users. Participants completed the screening version of the Hearing Handicap

Inventory for the Elderly/Adult (HHIE/A-S). A six-item health literacy assessment tool - the Newest Vital Sign (NVS) was administered by a research assistant during the initial visit. After a comprehensive hearing evaluation, all participants were given one direct-to-consumer hearing device that was trialed for an average of nine-weeks (ranged from 5-24 weeks). When participants returned for the final evaluation, aided soft speech audibility was measured through real ear measurement analysis. Participants filled out the 24-item Abbreviated Profile of Hearing Aid Benefit (APHAB) at both visits. The hearing device use benefit was obtained by calculating the score difference of the unaided and aided APHAB global score. The Institutional Review Board from Wayne State University approved this project.

Results: The Pearson correlation coefficient between the health literacy level and the hearing device use benefit was 0.6 (p = .0019). The results indicated that 32.5% of the variance in the hearing device use benefit can be explained by participants,Äô health literacy levels (F(1,25) = 12.0; p = .0019) from a stepwise multiple regression analysis.

Conclusions: The results from the correlation and regression analyses supported our hypothesis that older adults with poor health literacy would have worse clinical outcomes using hearing devices. Higher health literacy resulted in greater hearing device use benefit. It is possible that those with higher levels of health literacy tend to have efficient self-management skills of hearing loss, which result in better clinical outcomes. Although evidence is relatively limited in the hearing healthcare domain, understanding the mechanism linking health literacy to clinical outcomes may provide the key to improving access to affordable hearing healthcare.

Social Representation of Hearing Loss and Hearing Aids
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Objectives: Despite the negative consequences of hearing loss, people with hearing loss (PHL) wait about 10 years before seeking professional help and adopt hearing aid. Much of the knowledge in hearing help-seeking and hearing aid adoption have used attitude theories and stigma theory. However, the strategies developed based on these theories have not resulted in any substantial improvements to help-seeking behavior. Thus, it is essential to consider alternative theories (e.g., Theory of Social Representations) which have been successfully used in disability research to better understand how PHL perceives hearing loss and hearing aids to improve help seeking ad hearing aid adoption. The aim of the current study was to examine the social representation of hearing loss and hearing aids in PHL in India, Republic of Korea (ROK), United Kingdom (UK), and the United States (US). Social representation refers to values, practices, customs, ideas, and beliefs that are shared between individuals in a society or group.

Design: The study used a cross-sectional survey design. 424 participants were recruited using a consecutive sampling method in four countries (India, ROK, UK and US). Data was collected using a free association task self-reported questionnaire and analyzed using various qualitative (i.e., content analysis) and quantitative (similarities analysis, prototypical analysis, and Chi-square analysis) techniques.

Results: The free associations of the PHL relating to hearing loss were grouped into 37 categories. The most commonly reported categories were 'communication difficulties,' 'negative mental state,' 'ageing,' 'assessment

and management,' 'causes of hearing loss,' 'hearing ability or disability,' 'hearing instruments,' and 'symptoms of hearing loss.' Similarities analysis and prototypical analysis highlighted two main negative categories 'negative mental state' and 'communication difficulties' which form the central elements of social representation of hearing loss. PHL associated hearing loss mainly as a negative phenomenon but with some positive and neutral aspects. ROK respondents reported a greater number of neutral associations compared to other countries. In terms of the hearing aids, the free associations were grouped into 45 categories. The frequently reported categories across all countries were 'beneficial,' 'cost and time' and 'appearance and design.' Approximately 50% of the associations reported were negative. There were variations in terms of the categories that were predominant in the social representation of each country. 'Others' actions and attitude' category was predominantly reported by PHL in India. 'Disturbance' and 'dissatisfaction' of hearing aids and the 'repairs and maintenance of hearing aids' categories were mainly reported from the ROK and the US, respectively.Overall, there were cross cultural similarities and differences in PHL's social representation of hearing loss and hearing aids, although more similarities than differences were noted.

Conclusions: The study provides an insight into how PHL collectively view hearing loss and hearing aids. We believe that these findings will help to develop our understanding of the influence of culture on the social representation of hearing loss and hearing aids. The results will aid the development of culturally appropriate public education campaigns, marketing material and appropriate rehabilitation for PHL with the aim to improve help-seeking and hearing aid adoption.

Online Hearing Aid Consumer Reviews
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Objectives: The textual response of hearing aid consumer reviews can provide insights into the lived experiences of adult hearing aid owners regarding their acquisition and use of hearing aids, as well as users' satisfaction towards their device.

Design: Data entered on the HearingTracker.com website by members of the public who had obtained hearing aids via an in-clinic service with an audiologist were extracted and analyzed via three different methodological approaches to text analysis: (i) automated topic modelling, (ii) automated Linguistic Inquiry Word Count (LIWC), and (iii) traditional researcher-led qualitative content analysis.

Results: Consumer reviews (n=1,378) were both positive and negative in nature, although the vast majority of them were positive (i.e., mean rating of 4.04 in a 5-point scale). The topic modelling identified six clusters within two domains. Domain One (Device Acquisition) included the three clusters: Finding the right provider, device and price-point; Selecting a hearing aid to suit the hearing loss; and Attaining physical fit and device management skills. Domain Two (Device Use) included the three clusters: Smartphone streaming to hearing aids; Hearing aid adjustment using smartphone; and Hearing in noise. The automated linguistic analysis helped identify various psychological, social and clinic visit related language dimensions. Examining the association between overall rating and the key linguistic variables point to two broad findings. First, the more that people were personally, socially, and emotionally engaged with the hearing device experience, the higher they rated their hearing device(s). Second, a minimal occurrence of clinic-visit language dimensions points to factors that likely affect benefit and satisfaction ratings. For example, if people mention paying too much money their overall ratings were generally lower. Conversely, if people wrote about their health or home, the ratings were higher. There was no significant difference in linguistic analysis across different hearing aid brands and

technology levels. The qualitative content analysis resulted in identification of three domains, containing eleven themes and 136 sub-themes. Domain One (Clinical Processes) contained two themes: Hearing Assessment and Hearing Aid Acquisition. Domain Two (The Device) contained five themes: Function, Performance, Physical, Device Management and Maintenance. Domain Three (The Person) contained four themes: Satisfaction, Quality of Life, Personal Adjustment and Knowledge. Overall, the three different methodological approaches each provided unique contributions to understanding the dataset.

Conclusions: Although hearing aid owners indicate positive performance on multiple choice questions relating to hearing aid performance and benefit, they also describe a myriad of barriers limiting their success. Online reviews contain information about social/emotional dimensions as well as clinic-visit related aspects that have bearing towards hearing aid benefit and satisfaction ratings. These results suggest that, hearing healthcare clinicians must employ a patient-centred approach to audiological rehabilitation to ensure individual clients' needs are met.

Development of Portable Research Platforms for Advanced Hearing Aid Processing
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Objectives: A crucial step towards the target user groups' benefit from a novel hearing-device processing method is a systematic evaluation in realistic every-day life situations during its development phase. However, laboratory setups and computer simulations are usually limited to very controlled and simple acoustic situations, and often focused on a single algorithm that is considered in isolation from a complete hearing device processing chain that would be required for the final device. In order to test a new development in realistic usage scenarios in an early development stage, the Portable Hearing Laboratory (PHL) was developed, which allows for an easily accessible implementation of the algorithms under test and which resembles the relevant properties of a real hearing device, such as portability, proper ear-level devices as well as low-latency, real-time audio signal processing capability. The PHL forms a research tool that can be used in the laboratory in controlled virtual acoustic environments as well as in field studies. The objective of this contribution is to show current research done with the PHL, demonstrating its usefulness for hearing aid research.

Design: The Portable Hearing Laboratory (PHL) is an integrated research platform that has been developed in a project funded by the National Institutes of Health with the aim to provide researchers with open tools for hearing aid research. It consists of a single-board computer that was extended with a multi-channel audio board. In addition to the processing and audio board the integrated system includes a battery and a set of binaural behind-the-ear (BTE) hearing aids that comprise two microphones on each side to capture the sound field and receivers in the canal for the playback of processed audio signals. The light-weight system can be worn by a user using a neckband, the BTE devices are connected with the processing box via flexible cables. An optimized operating system is available that is tailored to performing low-latency signal processing on the processing board and runs a specific configuration of the open Master Hearing Aid (openMHA) software. openMHA is continuously further developed in order to meet new demands made by novel approaches in hearing aid research. Furthermore, reference implementations of hearing aid processing methods are provided that enable reproducibility of experimental setups of current research studies.

Results: In current and future developments several applications are developed based on the PHL for the investigation of a number of relevant topics in hearing device research: alternative forms of ear-level devices, in-the-field EEG data acquisition, advanced fitting strategies, low-latency remote streaming of audio data into hearing devices, and increasing the acoustic feedback stability of the device itself in order to reach a level that is comparable with commercially available end-user devices. Future hearing aid processing methods that incorporate deep learning techniques into hearing aid processing are also tackled.

Conclusions: The Portable Hearing Laboratory (PHL) running the openMHA software has already sparked a number of research studies in different centers, which shows its usefulness for the community.

PODIUM SESSION IV: SPEECH PROCESSING

Hemispheric Asymmetry of Speech-in-Noise Processing in Aided Hearing-Impaired Listeners
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Objectives: Late cortical auditory-evoked potential (CAEP) components tend to exhibit asymmetry favoring the left-hemisphere when evoked by rapid acoustic signals such as speech. Some have observed this leftward asymmetry to be disrupted by noise. Here, we analyze the hemispheric asymmetry of CAEP components previously recorded from aided listeners with a hearing loss as part of a study on noise-mitigating hearing aid technologies. We then explore whether the degree of hemispheric asymmetry may predict the benefit of noise-mitigating hearing aid features and/or listeners' speech-in-noise abilities.

Design: The study followed a double-blind within-subjects design. Nineteen older adults (8 females; mean age = 73.6 years, range = 56-86 years) with moderate-to-severe hearing loss were recruited for participation. The CAEP was evoked over 400 presentations of a synthetic /da/ stimulus which was delivered binaurally in a simulated aided mode using shielded ear-insert transducers. Sequences of the /da/ stimulus were presented from the front at 75 dB SPL-C with continuous speech-shaped noise (from the back) at SNRs of 0, +5, and +10 dB. Four hearing aid conditions were tested: (1) Omnidirectional Microphone (OM) mode with Noise Reduction (NR) disabled, (2) OM with NR enabled, (3) Directional Microphone (DM) mode with NR disabled, and (4) DM with NR enabled. Hemispheric asymmetries of the P1 component and N1P2 complex were quantified across electrodes spanning the mid-coronal plane. Subsequently, listener speech-in-noise performance was assessed using the Repeat-Recall Test (RRT) at the same SNRs and hearing aid conditions used to evoke the CAEP.

Results: As expected, both the P1 component and the N1P2 complex occurred earlier and were of greater amplitude over the left versus the right hemisphere. Moreover, linear mixed effects models suggested that the degree of asymmetry in the N1P2 complex accounted for a portion of variability in speech-in-noise performance that was not related to age, hearing loss, hearing aid processing, or SNR. The degree of asymmetry in the N1P2 complex was enhanced for the DM relative to the OM mode. Listeners with greater N1P2 asymmetries overall also exhibited larger disparities in CAEP amplitudes evoked in the DM versus the OM modes.

Conclusions: The responsiveness of left hemisphere auditory cortex to speech stimuli presented in noise may be predictive of behavioral speech-in-noise performance in listeners with a hearing loss and any benefit conferred thereupon by hearing aid processing that improves SNR.

Audiovisual Processing in Relationship to Phonological and Vocabulary Skills

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Objectives: While it is generally accepted that adults use these visual cues to improve speech intelligibility in noisy environments, the extent to which young children benefit from visual speech is less understood. Here, we focus on exploring the factors that contribute to audiovisual gain in speech understanding of young children. Specifically, we asked the following questions: 1) Is there audiovisual benefit to speech-in-noise recognition in children in first grade? 2) Do individual differences in audiovisual benefit relate to children‚Äôs overall performances on psychophysical tasks? 3) Is audiovisual benefit related to children‚Äôs vocabulary knowledge and phonological awareness skills?, and 4) Can first-grade children speech read in the absence of audio? We hypothesized that children of this age benefit from visual cues, particularly at lower signal-to-noise ratio (SNR). We also hypothesized that children‚Äôs audiovisual benefit is positively related to their vocabulary knowledge and phonological skills.

Design: We collected data from 37 first-graders in online psychophysical experiments. We used a single-interval, 4-alternative forced-choice (1I-4AFC) picture-pointing task with age-appropriate CVC-words to measure auditory-only, visual-only, and audiovisual word recognition in noise at -2 and -8 dB SNR. To confirm that children were capable of performing psychophysical tasks of similar complexity, we collected data from an unrelated 1I-4AFC psychophysical task, where children had to count 1-4 sine tones in similar SNR conditions without any visual help during stimulus presentation. We also obtained standard measures of vocabulary and phonological awareness. Data were analyzed using a mixed effects logistic regression and correlational analysis.

Results: We observed a significant overall audiovisual gain among children in first grade. This effect was mainly attributed to the benefit in the low SNR condition. Children performed significantly above chance in the speechreading condition (visual-only). Audiovisual benefit was not correlated with vocabulary. Surprisingly, AV benefit negatively correlated with phonological awareness. There was a very small positive correlation between the audiovisual benefit and the unrelated psychophysical task.

Conclusions: This study shows audiovisual benefit to word recognition in challenging noisy conditions in first graders. The task was designed to minimize the cognitive load of psychophysical testing, which may have minimized the impact of individual differences in vocabulary. The small positive correlation between both psychophysical tasks also shows the little impact of cognitive factors on these results . The fact that there is a positive correlation between the second psychophysical task and audiovisual performance could indicate higher working memory demands in the secondary task and the audiovisual trials. The negative relationship between AV benefit and the phonological awareness scores is not in line with our hypothesis or previous literature, we are continuing to explore this result in ongoing analyses.

Pupillary Response to Dynamic Pitch Manipulations During Speech Perception in Noise

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Objectives: Dynamic pitch, as defined by variation in fundamental frequency, is an acoustic cue that aids speech perception in noise. While the mechanisms that underserve this effect likely include enhanced perceptual

continuity and saliency, the behavioral measure of speech reception thresholds can fall short in capturing the effect of dynamic pitch cues during perception of speech in noise. Specifically, as an off-line measure, speech reception threshold does not reflect the momentary changes in perceptual/cognitive effort during the process of speech perception. Task-evoked pupillary response, which measures the instantaneous changes in pupil size as an indication of the cognitive load associated with an effortful task, has been used by previous research to study speech perception under adverse conditions. Built on this literature, the present study served as the initial step in using this technique to explore the effects of manipulated dynamic pitch cues in speech perception in background noise.

Design: In the experiment, we collected pupil response data during a speech recognition in noise task from a group of six younger listeners with normal hearing. The stimuli were low-context sentences that were produced by a female talker, embedded in non-speech noise that preserved the temporal and spectral characteristics of 2-talker babble. The pitch contour of the target speech was manipulated to create three levels of dynamic pitch strength (original dynamic pitch, strengthened dynamic pitch, and weakened dynamic pitch). Two conditions with signal-to-noise-ratio of -5 and -9 dB SNR were included to create difficulty levels ranging from fairly favorable to slightly more adverse, with speech recognition accuracy of 88% and 74% on average. The dependent measure was pupil diameter as relative to individuals‚Äô baseline level recorded at the beginning of each trial.

Results: Pupil diameter data were analyzed using growth curve analysis. Results to date showed weaker pupil responses with strengthened dynamic pitch and stronger responses with weakened dynamic pitch. Stronger pupil responses were demonstrated by faster increases of pupil dilation during unfolding of speech, and by higher maximum pupil sizes after speech signal ends. The effect of manipulated dynamic pitch also depended on noise condition and was stronger in the more favorable noise condition of -5 dB SNR.

Conclusions: The preliminary data support the feasibility of using pupil response to examine the effect of dynamic pitch cues on speech perception in background noise. The data suggest dynamic pitch manipulations affect perceptual/cognitive effort in perception of speech in noise. Importantly, this result is not evident based on the measure of speech recognition accuracy. As our next step, data will be collected from a larger sample of younger listeners with normal hearing and a group of older listeners with mild-to-moderate sensorineural hearing loss. Following this project, we plan to use this method to examine the role of dynamic pitch (and potentially other acoustic cues) in more realistic communication tasks and scenarios. The theoretical and clinical implications of this work will also be discussed. [Work supported by NIH]

Towards a Model of Speech-in-Speech Intelligibility
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Objectives: The speech intelligibility index (SII) does a good job of predicting speech-in-noise recognition, but fails when the background is itself composed of speech. A model of speech intelligibility in the context of other talkers would have applications in both basic research and clinical care, particularly in light of the functional importance of speech-in-speech recognition for everyday listening. The long-term goal of this research is to develop a model of speech intelligibility that can accommodate complex maskers like speech.

Design: Whereas the SII relies on data obtained with low-pass and high-pass filtered stimuli to determine band importance, this approach is not appropriate for speech-in-speech recognition due in part to effects of filtering

on informational masking. An alternative approach is proposed. Recognition is assessed with full-bandwidth speech-in-noise and speech-in-speech stimuli, and results are evaluated with respect to the short-term target-to-masker ratio (TMR) at the output of each channel in a bank of bandpass filters. The TMR is expected to positively correlate with the probability of a correct response, and the strength of this association across frequency is taken as an estimate of band importance.

Results: Preliminary data obtained using this method broadly replicate published band importance weights for speech-in-noise recognition, increasing confidence in this general approach. Weights differ for speech-in-noise as compared to speech-in-speech stimuli, however, indicating differences in reliance on audible speech cues distributed across frequency in steady noise vs. competing speech. Greater band importance applied to low frequencies in the speech masker could indicate reliance on low-frequency cues for auditory stream segregation.

Conclusions: The SII is often used to characterize the quality of speech cues available for a particular audiogram or intervention (e.g., to evaluate the quality of a hearing aid fit), or to compare results across interventions with the goal of maximizing outcomes. While more research is needed, results to date suggest that band importance differs for auditory environments containing noise and speech. If supported, a model of speech-in-speech recognition could be used in conjunction with the SII to guide intervention for patients with hearing loss.

Benefit of Visual Speech Cues and Sentence Context in Bilinguals
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Objectives: Background noise is virtually omnipresent in everyday listening environments. Despite this, most people perceive speech successfully when provided with supporting information. For example, it has long been known that visual speech cues (e.g., lip movements) and supportive sentence context both enhance speech perception in noise, at least in native listeners. Furthermore, these benefits are seen in a wide range of populations, including young adults, older adults with age-normative hearing, and older adults with hearing loss. However, comparatively little is known about those cues may help bilingual listeners who perceive speech in their second language. In this study, we examined the extent to which young and older bilinguals benefit from visual speech cues and sentence context during speech perception in noise in their first language (L1) and second language (L2).

Design: Participants were French-English/English-French bilinguals recruited from Concordia University as well as from the community in Montreal, Canada. They were divided into young adults (n = 32; 18-35 years) and older adults (n = 36; 60+). The latter group was further subdivided into older adults with age-normative hearing (n = 18) and older adults with age-related hearing loss (n = 18). All participants were presented with video-recorded sentences embedded in individually calibrated twelve-talker babble (i.e., equalized perceptual load). They were instructed to repeat the terminal word of each sentence. Half of the sentences provided moderate levels of context (e.g., "In the woods, the hiker saw a bear"), while the other 50% provided little context (e.g. "I have not thought about the bear"). Furthermore, the sentences were presented in three different modalities: visual-only, auditory-only, and audiovisual. Participants completed this task in both their L1 and L2.

Results: Overall, both young and older participants (with and without age-related hearing loss) benefitted from visual speech cues and sentence context to the same extent. Absolute speech in noise performance was lower in L2 compared to L1 for both age groups, but the magnitude of the benefits from visual speech cues and context was comparable between languages. In addition to these findings, we will discuss the extent to which one's ability to benefit from visual speech cues and sentence context in L1 and L2 is influenced by individual differences in L2 experience (e.g., age of acquisition, daily use) and cognitive ability (e.g., working memory).

Conclusions: Visual speech cues and supportive sentence context aid speech perception in noise in L1 and L2, for both young adults and older adults. Thus, in situations where access to accurate information is crucial (e.g., online education, medical settings), special attention should be placed on providing access to high-quality visual speech cues and abundant semantic context. This will provide native and non-native listeners with the most favourable conditions to access information, even in the context of adverse listening environments.

Pupil Dilation and Subjective Effort Across Vocoded and Noise Sentences
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Objectives: Across-study analyses of listening effort comparing vocoded speech to speech-in-noise stimuli generally conclude that responses behave in a similar manner: spectrally altering the signal alters listening effort. However, the differential effects of vocoded speech and speech-in-noise stimuli on objective and subjective listening effort within subjects remain largely unexplored. The present study sought to examine how different forms of challenging speech stimuli affect the task-evoked pupil response and subjective listening effort. We predicted that the vocoded stimuli would produce greater peak pupil dilation and subjective listening effort than performance matched speech-in-noise stimuli.

Design: Twenty adult volunteers with normal hearing listened to vocoded sentences and sentences in speech-shaped noise at fixed signal-to-noise ratios while peak pupil dilation measures were obtained. They were also asked to rate their subjective listening effort after the completion of each block of sentences. Peak pupil responses were analyzed using two methods: fixed difficulty level and by averaging responses together based on four word recognition ability categories (≤50%, 51-71%, 72-99%, and 100% correct).

Results: Peak pupil dilation and subjective listening effort were greater for the vocoded sentences than the sentences presented at fixed signal-to-noise ratios despite statistically similar word recognition abilities. During ceiling performance, peak pupil dilation for the vocoded sentences remained greater than the sentences in noise. When analyzed by word recognition ability, peak pupil dilation increased as performance decreased but was no longer significantly different across the vocoded sentences and sentences in noise.

Conclusions: Vocoder simulations affect listening effort differently than speech-in-noise stimuli. While speech understanding is generally similar across these different stimuli, maintaining proficiency while listening to vocoded speech requires greater physiologic and subjective listening effort. Furthermore, this effect is preserved when speech is perfectly understood, but eventually disappears as participants' word recognition abilities decline. Therefore, across-study comparisons of listening effort using different methods of spectral manipulation as well as assumptions about cochlear implants users based on vocoder simulations should be performed with caution.

PODIUM SESSION V: TINNITUS, TOXICITY, AND TRAUMA

Internet-based Cognitive Behavioral Therapy: Results of two U.S.RCTs

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Objectives: Many experiencing troublesome tinnitus remain without access to tinnitus treatment due to geographical or service constraints. Furthermore, evidence-based tinnitus interventions such as cognitive behavioral therapy are not always readily available. To increase access to such an evidence-based intervention, an Internet-based cognitive behavioral therapy intervention (ICBT) was designed. Clinical trials in Europe have indicated efficacy, but this intervention has not been used in the U.S. This talk describes the results of randomized clinical trials (RCTs) undertaken to evaluate the efficacy of audiologist-guided ICBT in a U.S. population of two different trial designs

Design: Both studies used two armed RCTs design with the first trial using a delayed treatment design using a weekly check-in control group, whereas the second trial used a parallel design. The first RCT (n = 158), the experimental group received ICBT treatment for 8 weeks while the control group were monitored weekly. After the 8-week period the control group also received the ICBT intervention. For this trial only participants with tinnitus severity scores greater and 24/100 for the TFI and no indications of high depression scores were included. For the second RCT (n = 126, the experimental group received ICBT treatment for 8 weeks while the control group received the relaxation component only. After the 8-week period the control received the CBT components. Participants for this trial, participants were included irrespective of their tinnitus severity and depression severity levels. For the trials described the primary outcome was a change in tinnitus distress as measured by the Tinnitus Functional Index (TFI). Secondary outcome measures included measures of anxiety, depression, insomnia, tinnitus cognitions, hearing-related difficulties, and health-related quality of life.

Results: For the first trial, those undertaking the ICBT intervention had a greater reduction in tinnitus distress when compared with the weekly check in control group. The experimental group also had a greater reduction for insomnia, tinnitus cognitions and hearing-related effects post intervention. These results were clinically significant and maintained 2 months postintervention. For the second trial, no differences were found between those completing the full CBT program and those doing the relaxation only component for tinnitus severity and all secondary outcomes. During subgroup analysis in the in the tinnitus severity scores greater and 24/100 and those with high depression scores showed significant improvements at post intervention, regardless of whether they did the full CBT program or the relaxation components. Those with low tinnitus severity showed no significant changes in their tinnitus severity scores regardless of their group allocation.

Conclusions: These results are comparable to results found using ICBT in Europe. It indicates the potential of audiologist-guided ICBT to increase accessibility and affordability of evidence-based tinnitus care in the US. It also provides useful insights into the components of the intervention that are helpful and which groups of the tinnitus population this intervention is most suited for. Further research is required to investigate predictors of outcome and long-term outcomes. Further refinements are indicated to improve intervention engagement.

Tinnitus Epidemiology: National Longitudinal Study of Adolescent and Adult Health

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Objectives: To estimate prevalence and incidence of tinnitus among adults aged 24-42 years and identify risk factors associated with tinnitus.

Design: The National Longitudinal Study of Adolescent and Adult Health (aka, Add Health) is an ongoing longitudinal study of a nationally representative cohort of approximately 15,000 youths in the United States. Participants were drawn from a school-based sample of students, Grades 7-12 in 1994-1995 (aged 12-19), and have been followed for five cycles. Participants in Wave 4 (2008; aged 24-32, n=15,701) and Wave 5 (2016-2018; aged 32-42, n=14,738) were asked: "In the past 12 months have you been bothered by ringing, roaring, or buzzing in your ears or head (tinnitus) that lasts for 5 minutes or more?" Other questions asked about frequent headaches, head trauma/concussion, hearing ability, and sociodemographic variables (age, sex, race/ethnicity, education). We used multivariable logistic regression to estimate odds ratios (OR) with 95% confidence intervals (CI) to examine associations between reported tinnitus with sociodemographic variables, sensory (hearing and/or balance/vestibular problems), and other neurologic and mental health conditions.

Results: Prevalence of tinnitus was 6.7% (males, 7.3%; females, 6.1%) in Wave 4 and 11.7% (males, 13.0%; females, 8.9%) in Wave 5. Persistent tinnitus (Waves 4 and 5) was reported by 0.8%, whereas 10.3% reported tinnitus in Wave 5 only. In Wave 5, prevalence was 12.1% for Non-Hispanic (NH) white, compared to 8.7% Hispanic, 8.1% NH black, and 6.9% Asian race/ethnicity, p<0.001. Tinnitus prevalence increased as hearing status changed from "excellent" (4.9%) to just "good" (11.1%), "a little trouble" (28.1%), and "moderate or worse trouble" (53.8%), p<0.001. Tinnitus prevalence increased for those with history of head trauma/concussion (21.7%) versus those without head trauma/concussion history (9.2%), p<0.001. Higher prevalence was associated with history of frequent headaches (18.8%) versus those without frequent headaches (8.8%), p<0.001. In Wave 5, multivariable models (included age, sex, race/ethnicity, education, head trauma, headache, depression, anxiety) found: male sex (OR=1.9; 95% CI: 1.5-2.7); head trauma/concussion (OR=1.5; CI: 1.2-1.9); frequent headaches (OR=1.8; CI: 1.5-2.2); anxiety (OR=1.3; CI: 1.0-1.6); dizziness and balance problems past year (OR=2.7; CI: 2.2-3.3); and report of "excellent" versus "good" hearing (OR=2.1; CI: 1.7-2.7), "a little trouble" (OR=6.2; CI: 4.8-8.0), and "moderate or worse trouble" (OR=16.2; CI: 10.9-24.1). In multivariable models, persistent tinnitus in Waves 4 and 5 was significantly associated with age in years (OR=1.15; CI: 1.02-1.3); head trauma/concussion (OR=1.3; CI: 1.1-3.6); frequent headaches (OR=2.3; CI: 1.3-3.9); dizziness and balance problems (OR=3.3; CI: 1.8-5.9); and report of "a little trouble" hearing (OR=7.6; CI: 2.7-21.4) and "moderate or worse trouble" hearing (OR=13.3; CI: 3.5-49.9).

Conclusions: Tinnitus is common among young adults. Risk factors for persistent tinnitus included age, head trauma, frequent headaches, dizziness/balance problems, and hearing loss. Tinnitus reported by most young adults (aged 24-32) appears to resolve over time. However, when re-interviewed eight- to ten-years later, 10% of subjects (aged 32-42) reported onset of tinnitus between Waves 4 and 5. It will be important to ascertain tinnitus status in subsequent Waves of the Add Health cohort to understand changes in prevalence of persistent tinnitus with age.

Differences Among Tinnitus Subgroups in Tinnitus Quality, Distress, and Characteristics
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Objectives: The primary aim of this study was to determine differences in tinnitus qualities between subgroups of tinnitus patients using a large tinnitus clinical population. Previous studies have reported differences in tinnitus subgroups across variables such as gender, duration of tinnitus, and tinnitus loudness ratings. However, past studies have not recruited a sufficient number of participants per subgroup or have classified groups through coding rather than cluster groupings that negatively affected the results.

Design: We recruited 804 participants for this study using two different methods ‚Äì 335 from the University of Iowa Tinnitus Research patient database and 449 from a web survey conducted by the University of Iowa. All participants completed three tinnitus questionnaires either online through a secure web portal or in-person at the University of Iowa. The questionnaires assessed tinnitus severity, reactions to tinnitus, and tinnitus characteristics such as pitch, loudness, duration since onset, and location. We grouped participants based on their tinnitus type that was classified as either tonal, noise-like, cricket-like, or other/pulsing consistent with previous research studies on tinnitus subgrouping. We compared group differences using analysis of variance tests and completed linear regression analyses to investigate predictive relationships between tinnitus characteristics and the questionnaire scores.

Results: Tonal tinnitus was the most reported tinnitus type similar to previous study's findings. We found that the tonal tinnitus group reported a significantly higher pitch compared to the other three groups. Results also revealed a significant difference among groups for the severity of their tinnitus. The tonal tinnitus group reported the lowest scores for tinnitus severity and the other/pulsing group had the highest tinnitus severity scores. We did not find a significant difference across subgroups in how tinnitus affects their sleep, concentration, and thoughts or emotions, though a trend towards significance was observed for the effect on communication abilities across groups. Regression analyses revealed that tinnitus loudness and duration of tinnitus were significant predictors for tinnitus questionnaire scores. Tonal subgroup was a significant predictor for one of the tinnitus questionnaires.

Conclusions: These findings from a large number of tinnitus patients suggest that the type of tinnitus percept likely influences the severity of their tinnitus. Patients with a tonal tinnitus may be able to better cope with their tinnitus compared to participants with a tinnitus type that varies in pitch or loudness. Other factors such as the duration of tinnitus, along with the loudness of tinnitus, may impact the ability to cope with it. We plan to examine additional factors such as the cause of tinnitus across subgroups in future studies.

Reduced Cisplatin-Induced Hearing Loss in Cancer Patients Taking Statins

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Objectives: Cisplatin is widely used to treat adult and pediatric cancers. It is the most ototoxic drug in clinical use. Over 50% of patients treated with cisplatin therapy acquire permanent sensorineural hearing loss, which compromises daily communication with friends, family, and healthcare providers and can lead to loneliness, social isolation and frustration. There is a major need for therapies that prevent or reduce cisplatin-induced hearing loss. Statins are a class of FDA- approved drugs used primarily for the treatment of hyperlipidemia. Studies in mice suggest that concurrent use of statins reduces cisplatin-induced hearing loss. This study was designed to examine the effect of concurrent statin use on cisplatin-induced hearing loss in patients with head and neck cancer. We hypothesized that statin users would have reduced cisplatin-induced hearing loss relative to statin non- users.

Design: We conducted an observational clinical study to examine hearing thresholds from 277 (234M, 43F) patients treated with cisplatin for head and neck cancer. Approximately 40% of patients were taking a statin medication at the time of cisplatin treatment. Pre-cisplatin treatment and post-cisplatin treatment audiograms were obtained. Threshold shifts were calculated as the difference in behavioral thresholds obtained at baseline (≤90 days pre-cisplatin therapy) and follow-up (≤90 days after cessation of cisplatin therapy) visits. We applied change in hearing criteria, based on threshold shift data ranging from 1 to 8 kHz, defined by the National Cancer Institute's Common Terminology Criteria for Adverse Events (CTCAEv5.0) and compared the incidence and severity of cisplatin-induced hearing loss between patients taking a statin versus those not taking a statin, controlling for treatment and baseline patient characteristics including age, sex, pre-existing hearing loss, radiation and cumulative cisplatin dose. Additional analyses were conducted comparing statin non-users versus more commonly used statins including atorvastatin and simvastatin.

Results: Threshold shifts at frequencies ≥4 kHz were significantly reduced among patients taking any statin drug during cisplatin therapy relative to statin non-users. A mixed effect model analysis controlling for sex, age, radiation exposure, cumulative cisplatin dose, and pre-existing hearing loss showed that, in addition to cumulative cisplatin dose and pre-existing hearing loss, atorvastatin in particular was significantly associated with reduced high frequency (4 – 8 kHz) hearing loss. Applying CTCAEv5.0 criteria to threshold shift data, the overall incidence in a Grade 1 or higher CTCAE-defined hearing loss was significantly reduced from 49% in statin non-users to 38% in statin users and to 31% in atorvastatin users. Additionally, the incidence of a CTCAE grade ≥2 hearing change was significantly reduced from 29% in statin non-users to 9.7% in atorvastatin users. Importantly, three-year survival rates were not different between atorvastatin users and statin non-users.

Conclusions: Our results indicate that statin use, and atorvastatin use in particular, is associated with reduced incidence and severity of cisplatin-induced hearing loss in adults with head and neck cancer. Atorvastatin, an inexpensive drug with a good safety profile, holds promise to reduce cisplatin-induced hearing loss in adult patients without reducing the therapeutic efficacy of cisplatin.

Exploring Tinnitus Subgroups
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Objectives: Variable outcomes following the provision of tinnitus interventions are commonly reported, which may be related to the heterogeneity of the condition. Subgrouping (i.e. phenotyping) those with tinnitus, so that tailored interventions can be implemented, may reduce outcome variability. There is, however, no universally accepted way of classifying individuals with tinnitus. The purpose of this study was (1) to test if the presence of tinnitus subgroups can be discerned based on tinnitus severity and hearing-related comorbidities, and (2) to identify predictors of tinnitus severity for each subgroup identified.

Design: Tinnitus heterogeneity was explored from two approached using exploratory cross-sectional study designs. The first approach subdivided 326 adults seeking help for tinnitus into subgroups of those with mild, significant and severe tinnitus. For the second approach, cluster analysis was used to identify if unique subgroups based on hearing-related comorbidities were present for a sample of 2,980 adults with tinnitus. For both approaches, multiple regression identified individual characteristics associated with greater tinnitus severity in each subgroup.

Results: During the first approach, distinct subgroups based on tinnitus severity were found. Insomnia, hearing distress, and anxiety were the best predictors of tinnitus severity (explaining 53% of the variability). These comorbidities were stronger predictors than any demographical factors (that explained 11% of the variability). Distinct subgroups based on tinnitus severity (mild, significant, and severe) and anxiety levels were evident. Those with severe tinnitus had significantly more severe comorbidities compared with the mild and significant groups. For the second approach, a three-cluster solution identified distinct subgroups, namely tinnitus-only individuals (44%), those presenting with tinnitus and hyperacusis (27%), and those with tinnitus and hearing loss (29%). Younger age and the presence of mental health problems predicted significantly greater tinnitus severity for all groups. Being a hearing aid user, diagnosis of physical health problems or having previously sought treatment for tinnitus, predicted higher tinnitus severity for the tinnitus-only group. In addition, a shorter duration since the onset of tinnitus and previously seeking treatment for tinnitus predicted more severe tinnitus for the group with comorbid tinnitus and hearing loss.

Conclusions: Further exploration of these potential subtypes are needed in both further research and clinical practice by initially triaging tinnitus patients prior to their clinical appointments based on the presence of hearing-related comorbidities and/or tinnitus severity. Unique management pathways could be considered for each tinnitus subgroup, whereby individuals presenting with characteristics that put them at risk for greater tinnitus severity could be directed to more immediate and intensive interventions.

Sound-Level Monitoring Earphones With Smartphone Feedback as an Intervention
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Objectives: More than a billion adolescents and youngsters are estimated to be at risk of acquiring recreational noise-induced hearing loss (RNIHL) due to the unsafe use of personal audio systems (PAS). RNIHL is preventable, therefore, the present study aimed to determine (i) the accuracy and reliability of dbTrack

(Westone) sound-level monitoring earphones and (ii) the effect of sound-level monitoring earphones with smartphone feedback and hearing health information as an intervention to promote healthy listening behaviors in young adults.

Design: The study consisted of two phases, the first phase investigated the accuracy and reliability of dbTrack (Westone) sound-level monitoring earphones. Accuracy was determined by comparing earphone measurements to sound level meter measurements. Intra-device reliability was determined by comparing earphone measurements during test-retest conditions. Nineteen participants were recruited through convenience sampling to determine within-subject reliability by comparing in-ear sound levels measured by the earphones during test-retest conditions. For the second phase of the study, a single-group pretest-posttest design was utilized. Forty participants, recruited through snowball sampling, utilized dbTrack (Westone) sound-level monitoring earphones with the accompanying dbTrack smartphone application for 4 weeks. The application's smartphone feedback was disabled during the first 2 weeks (pretest condition) and enabled during the last 2 weeks (posttest condition). Average daily intensities, durations and sound dosages measured during pre- and posttest conditions were compared.

Results: Phase 1 dbTrack (Westone) sound-level monitoring earphone measurements were within 1 dB when compared to sound level meter measurements. Earphones were also within 1 dB in repeated measures across earphones and across participants. Phase 2 posttest average daily intensity decreased by 8.7 dB (18.3 SD), duration decreased by 7.6 minutes (46.6 SD) and sound dose decreased by 4128.4% (24965.5% SD). Differences in intensity and sound dose were significantly lower with a small and medium effect size, respectively.

Conclusions: dbTrack (Westone) sound-level monitoring earphones with a calibrated in-ear microphone can reliably and accurately measure PAS sound exposure. Feedback on sound exposure using the accurate sound-level monitoring earphones with the accompanying dbTrack application can potentially promote safe listening behavior in young adults and reduce the risk of acquiring an RNIHL.

Analgesic Use and Risk of Incident Tinnitus
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Objectives: Tinnitus is a complex and heterogeneous condition that affects ~15% of the population, causing considerable distress and disability. Although millions of people worldwide suffer with tinnitus, the causes are not well understood and there is no cure. The analgesics acetaminophen, ibuprofen, and aspirin are among the most commonly used medications in the US. While high doses of aspirin may cause reversible tinnitus, the associations between use of typical dose aspirin and of other commonly used analgesics and risk of incident tinnitus have not been prospectively studied. Therefore, we conducted a longitudinal investigation of the associations between use of acetaminophen, ibuprofen, and typical-dose aspirin and risk of incident tinnitus in a large female cohort.

Design: We conducted a 22-year longitudinal study among 64,002 women, aged 30-44 years and without tinnitus at baseline, who were participants in the Nurses' Health Study II (1995-2017). Information on analgesic use, a wide range of demographic, anthropomorphic, medical, diet and lifestyle factors, and tinnitus was obtained from was obtained from biennial questionnaires. Persistent tinnitus was defined as tinnitus several days per week or more. In additional analyses, we examined alternative definitions of tinnitus, such as persistent

tinnitus lasting 5 minutes or more and bothersome tinnitus that interfered with work, sleep, or daily activities. Age- and multivariable-adjusted relative risks (MVRRs) were calculated using Cox Proportional Hazards regression models to evaluate the independent associations of acetaminophen, ibuprofen, and aspirin use and risk of incident tinnitus.

Results: During 1,321,968 person-years of follow-up, 11,024 cases of incident persistent tinnitus were reported. Acetaminophen and ibuprofen use were each associated with higher risk of tinnitus and the magnitude of the risk tended to be greater with more frequent use. Specifically, compared with women who did not use acetaminophen, the MVRR (95% CI) among women who used acetaminophen 2-3 days/week was 1.11 (1.03, 1.20); 4-5 days/week was 1.19 (1.06, 1.34); and 6-7 days/week was 1.29 (1.17, 1.41)(p-trend<0.001). Similarly, compared with women who did not use ibuprofen, the MVRR (95% CI) among women who used ibuprofen 2-3 days/week was 1.10 (1.03,1.16); 4-5 days/week was 1.17 (1.08,1.27); and 6-7 days/week was 1.09 (1.00, 1.18)(p-trend<0.001). Frequent use of aspirin was marginally significantly associated with a modest lower risk of tinnitus; compared with women who did not use aspirin, the MVRR (95% CI) among women who used aspirin 2-3 days/week was 1.03 (0.94, 1.14); 4-5 days/week was 0.92 (0.82, 1.02); and 6-7 days/week was 0.95 (0.90, 1.00). Further adjustment for hearing status did not alter the results. Examination of alternative definitions of tinnitus yielded similar findings.

Conclusions: Frequent use of acetaminophen and of ibuprofen was associated with higher risk of tinnitus and the magnitude of the risk was greater with more frequent use. Surprisingly, there was a suggestion of a modest inverse association with aspirin use. Given the previously found associations with hearing loss and these new findings that frequent use of acetaminophen or ibuprofen may be important preventable contributors to tinnitus, individuals should be counseled regarding their potential ototoxicity.

Association of Prenatal Exposure to Tobacco and Alcohol on Neonatal Auditory System

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Objectives: Prenatal exposures to alcohol (PAE) and tobacco (PTE) are known to produce adverse neonatal and childhood outcomes including damage to the developing auditory system. This study constitutes a portion of the physiology measurements from the Safe Passage Study. The goal of this study was to prospectively document prenatal exposures including alcohol and tobacco in a diverse cohort and to determine the effects of such exposures on the neonatal auditory system. Knowledge of the timing, extent, and combinations of these exposures on effects on the developing system will aid in understanding the mechanisms involved.

Design: Auditory Brainstem Responses (ABRs) and Transient Otoacoustic Emissions (TEOAEs) were acquired on infants at birth and one month of age. Research centers were located in South Africa and the Northern Plaines of the US. Prenatal information on alcohol and tobacco exposure was gathered prospectively on mother/infant dyads. Cluster analysis was used to characterize three levels of PAE and PTE. Repeated-measures ANOVAs were calculated for data from newborn and one-month-old infants for ABR peak latencies and

amplitudes, three peaks and two ears, and TEOAE levels and signal-to-noise ratios by six frequencies and two ears. Effects of PAE, PTE and interactions were calculated with controls for hours of life at test, gestational age at birth, sex, and site

Results: A significant main effect of PTE was found for newborn ABR peak latencies elicited from the right (p=0.001) and from the left ear (p=0.026). Responses showed a reduction in latency with tobacco exposure. PTE resulted in significant reduction of ABR peak amplitude elicited from the right ear (p=0.001) and left ear (p=0.004) in one-month old infants. PAE effects were found in a reduction of TEOAE amplitude for one - month old infants but only in the left ear (p=0.011).

Conclusions: Results are consistent with early disruption of neuronal pathways, in particular, the olivocochlear pathway and synaptic function in cochlea and auditory brainstem.

PODIUM SESSION VI: POPULATION STUDIES

Mid-to-Late Life Blood Pressure Patterns and Late-life Hearing Loss

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Objectives: Hypertension has been considered as a risk factor of age-related hearing loss, potentially through inadequate cochlear blood flow as well as structural and functional changes in the brain. Findings from cross-sectional epidemiologic studies of the association between hypertension and hearing loss are inconsistent and longitudinal studies have failed to clearly demonstrate an association over time. This study aims to examine the association of blood pressure patterns from mid-life to late-life with late-life hearing loss.

Design: We studied 3,341 participants, from an ongoing prospective cohort study, the Atherosclerosis Risk in Communities Study with complete audiometric and speech-in-noise data. Audiometric and speech-in-noise testing was conducted at Visit 6 (2016-17). A four-frequency (0.5, 1, 2, 4 kHz) pure tone average (PTA) was calculated in the better-hearing ear. Central auditory processing was measured by the Quick Speech-in-Noise (QuickSIN) test, which was modeled as the average of the two lists (range 0 -30). Hypertension was defined by measured systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg, or by self-reported antihypertensive medication use. Participants meeting the definition for hypertension for at least 2 consecutive visits between Visits 1 (1987-89) and 4 (1996-98) were classified as having mid-life hypertension. All other participants were considered midlife normotensive. Late-life blood pressure status (normotension, low blood pressure (BP), or hypertension) was defined at the same time that hearing was measured (Visit 6, 2016-17). Late-life hypertension was defined as for prior visits, and late-life low BP was defined as measured SBP<90 mmHg or measured DBP<60 mmHg, irrespective of antihypertensive medication use. Participants were grouped into 5 categories of mid-to-late-life blood pressure patterns: (1) normotension in both mid- and late-life; (2) mid-life normotension and late-life hypertension; (3) mid-life normotension and late-life low BP; (4) mid-life hypertension and late-life hypertension; (5) mid-life hypertension and late-life low BP. Participants with mid-life hypertension and late-life normotension were excluded due to small numbers. Multivariable-adjusted linear regression was used to estimate the association of categories of mid-to-late-life blood pressure patterns with PTA and with QuickSIN score measured at Visit 6 (2016-17). Models were adjusted for age, sex, race-center, education, body mass index, smoking status, drinking status, noise exposure and diabetes.

Results: When compared to participants with normotension in both mid-life and late-life, persistent hypertension was associated with significantly lower QuickSIN scores (-0.60, 95% CI: -1.07, -0.13), suggesting poorer late-life central auditory processing. No associations between mid-to-late-life blood pressure patterns were observed with PTA.

Conclusions: Persistent hypertension from mid-life to late-life is associated with poorer late-life central auditory processing, but not with pure tone audiometry, suggesting that hypertension may be more strongly related to hearing-related changes in the brain compared to in the cochlea. Therefore, management of hypertension may have impacts on improved hearing, primarily through cognitive processing.

Impacts of Face Coverings on Hearing and Communication
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Objectives: Face coverings are now mandatory, or at least ubiquitous, around the world. While a few studies have investigated the acoustic impacts of wearing a face covering, we were unaware of any that examined user perspectives on hearing and communication. To that end, the purpose of this study was to understand the impact

of face coverings on hearing and communication. to gain insights into experiences of interactions involving face coverings, and of the impact of face coverings on communication.

Design: The survey was completed by 463 members of the UK general public. They were recruited via snowball sampling. People with hearing loss were intentionally oversampled to more thoroughly assess the effect of face coverings in this group. Survey questions were designed to cover a wide range of listening situations and social interactions, and examined experiences of communicating when wearing a face covering and when interacting with someone else wearing a face covering. Both closed-set and open-ended questions were used.

Results: With few exceptions, participants reported that face coverings negatively impacted hearing, understanding, engagement, and feelings of connection with the speaker. Impacts were greatest when communicating in medical situations. People with hearing loss were significantly more impacted than those without hearing loss. Face coverings impacted communication content, interpersonal connectedness, and willingness to engage in conversation; they increased anxiety and stress, and made communication fatiguing, frustrating and embarrassing - both as a speaker wearing a face covering, and when listening to someone else who is wearing one.

Conclusions: This study has revealed that face coverings have far-reaching impacts on communication for all individuals and, as expected, they impact people with hearing loss significantly more than those with normal hearing. These findings represent a call to action to acousticians and industrial designers to develop communication-friendly face coverings, to healthcare providers to ensure they address the communication needs of their patients, and to the general public to use good communication tactics when wearing a face covering.

Hearing Loss and Smoking: National Health and Nutrition Examination Survey
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Objectives: A positive association between tobacco smoking and hearing loss has been reported in numerous studies. With increasing legalization and availability of cannabis, the prevalence of cannabis smoking in the United States is on the rise while tobacco use is declining. Yet few laboratory studies have examined the relationship between cannabis use and auditory function and no population-based studies have been conducted. We explored this relationship hypothesizing that, compared to not smoking, cannabis and tobacco smoking would be associated with increased odds of hearing loss.

Design: This cross-sectional study used data from the National Health and Nutrition Examination Survey (NHANES; 2011-12 and 2015-16 cycles). Participants were aged 20-59 years (56.7% female). The main outcome was hearing loss defined as puretone average (PTA) in the poorer ear >25 dB HL at low (0.5-2 kHz) and high (3-8 kHz) frequencies. Smoking status was categorized into four mutually exclusive groups (non-smoker [n=1511], tobacco smoker [n=228], cannabis smoker [n=208], or both [n=385]). Tobacco use was defined as currently smoking every day or some days. Cannabis smokers reported smoking marijuana at least once per month for more than one year and smoking within the last 30 days. Co-drug users reported current use of both tobacco and cannabis. Multivariable adjusted logistic regression was used to examine associations between smoking (tobacco, cannabis, or both) and hearing loss (based on PTA[0.5,1,2], PTA[3,4,6,8], and at discrete audiometric frequencies) adjusting for confounders (age, sex, race/ethnicity, education, hypertension,

diabetes, noise exposure, firearm use, and Veteran status) with sample weights applied. Analyses were sex stratified.

Results: The weighted prevalence of hearing loss based on PTA[0.5,1,2] was highest amongst co-drug users (6.27% [SE=1.48]) followed by tobacco smokers (6.1% [SE=1.84]) and cannabis smokers (3.4% [SE=1.76]). Non-smokers had the lowest prevalence of low frequency hearing loss (3.0% [SE=0.60]). Based on PTA[3,4,6,8], the highest prevalence of hearing loss was observed in co-drug users (32% [SD=4.26]) and the lowest prevalence in cannabis smokers (17.08% [SE=3.01]). For women, tobacco smoking and co-drug use were significantly associated with low frequency hearing loss (PTA0.5,1,2; multivariable adjusted odds ratio [MVOR]=3.44 [95% CI, 1.32-8.97] and 4.45 [1.52-13.0] respectively). Tobacco smoking and co-drug use were also associated with high frequency hearing loss (PTA[3,4,6,8]; MVOR=1.75 [95% CI, 1.12-2.73] and 2.12 [1.18-3.79] respectively). Cannabis use was associated with hearing loss at 0.5 kHz (MVOR=5.92 [95% CI, 1.31-26.81]) and 1 kHz (MVOR=5.22 [95% CI, 1.41-19.35]). For men, co-drug users had increased odds of hearing loss at 6 kHz (MVOR=1.66 [95% CI, 1.03-2.70]); no other associations were significant.

Conclusions: Preliminary findings from this nationally representative study support an association between hearing loss and smoking (tobacco and co-drug use) among women. Cannabis smoking was associated with low frequency hearing loss. However, these relationships were not observed in men. The results should be interpreted cautiously as the prevalence of low frequency hearing loss was low. Tobacco smoking may be a modifiable risk factor for hearing loss, particularly among women. Evidence supporting a relationship with cannabis smoking is weak. Future large-scale studies may explore the possibility of subclinical auditory deficits in cannabis smokers.

Presbycusis Treatment and Falls Prevention: A Scoping Review
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Objectives: As the leading cause of fatal and non-fatal injuries among older adults, falls are a significant public health problem. Presbycusis – or age-related hearing loss – is a common condition postulated to affect falls through antecedents such as balance. It is unknown whether intervening on presbycusis impacts falls risk. This review assesses the scope of evidence measuring the association between presbycusis interventions, falls-related antecedents, and the risk of falls. We aim to:• Identify which disciplines generated literature researching the above associations,• Document definitions of presbycusis and methods used to ascertain this condition,• Document interventions considered in the presbycusis treatment literature, • Document definitions of falls and fall-related antecedents and methods used to ascertain them, • Qualitatively summarize findings from existing literature.

Design: On July 16, 2020 we searched Ovid Medline, Embase, CINAHL, PsycINFO, Cochrane Reviews, and Cochrane Trials for references published during or after 2000 investigating presbycusis treatment, falls, and its antecedents. We conducted this review on the Covidence platform and adhered to PRISMA Extension for Scoping Reviews guidelines. During title/abstract and full-text screening, two research team members independently reviewed each reference. Interrater reliability ranged from moderate-to-substantial-agreement

during title/abstract screening ($\_$ = 0.48 – 0.69), and moderate-to-near-perfect-agreement during full-text review ($\_$ = 0.67 – 0.90). We resolved conflicts by consensus vote. We applied the following screening criteria:1. Contains original data,2. Includes adults age 50 + either as the entire sample, majority of the sample, or separately analyzed strata, 3. Includes a hearing intervention (e.g. non-implanted hearing aid, hearing rehabilitation, personal sound amplification product, or a combination of these),4. Addresses fall-related outcomes (e.g. falls, injurious falls resulting in hospitalization or emergency department care, fear of falling, balance, postural stability),5. Investigates a relevant comparison (e.g. aided vs. unaided between-persons or groups; aided vs. unaided within-person; hearing aid on vs. off), 6. Published during or after calendar year 2000,7. Hearing loss is sensorineural age-related. We assumed hearing loss was age-related unless the authors explicitly stated another cause like congenital impairment or occupational noise exposure.

Results: Of the 9,842 references retrieved, 4,695 duplicates were removed , and 199 met title/abstract screening criteria to be considered for full-text review. Eleven references qualified for data abstraction after full text review. Disciplines investigating the relationship between treating presbycusis and falls include audiology, epidemiology, health economics, physical therapy, and kinesiology. We identified 7 unique hearing loss measures, 13 falls/balance measures, and 4 hearing aid use measures. Five references indicated improved balance or lower falls risk among hearing aid users, 1 reference indicated higher falls risk, 3 references indicated null effects, and 2 require further follow-up with the study authors.

Conclusions: Initial data show heterogeneity in the measurement of presbycusis, hearing aid use, falls, and its antecedents. The association between presbycusis treatment and falls is mixed – likely due to varying exposure, outcome, and comparison group definitions. We anticipate that findings from this review will inform best practices in the design of future definitive studies answering the question, 'Should hearing aids be used as a public health intervention to prevent falls among people with presbycusis?'

Racial/Ethnic and Sex Representation in Hearing-Related U.S.-Based Clinical Trials
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Objectives: Although the National Institutes of Health (NIH) mandated the inclusion and reporting of women and minorities in NIH-funded research in 1993, little is known regarding the representation of women and minorities in trials investigating hearing loss management. Despite efforts by the NIH and, more specifically, the Office of Research on Women's Health to increase the enrollment of minority and women in clinical trials, subgroup reporting in publications is largely accepted as a general guideline rather than a formal requirement. The United States has taken active steps to improve the recruitment, retention, and reporting of minority study participants in clinical research through the installation of resources provided by the NIH, including the "All of Us" initiative and Enhancing Minority Participation in Clinical Trials website, developed to create a more culturally representative health network. As the current emphasis on improving the representation of underrepresented minorities and women in clinical trials remains a critical priority, our study aims to assess sex and racial/ethnic representation in United States-based clinical research studies of hearing loss management in an adult population.

Design: The study team identified pertinent studies for review, using search strategies in PubMed, Embase, and ClinicalTrials.gov. Our search strategy included the key subjects "bilateral hearing loss," "ageing," and

"controlled clinical trial," and yielded 6,196 studies. We included trials written in English, performed in the United States, and evaluated hearing loss management including amplification devices such as hearing aids or assistive listening devices, cochlear implants, aural rehabilitation, and therapeutics, among an adult population. Information from a total of 125 studies were extracted. The standard PRISMA diagram for systematic review was used for abstracting data and assessing the validity and quality of findings. The guidelines were applied using independent extraction by multiple observers.

Results: Among 125 clinical studies performed in the U.S. from 1990 to 2020 regarding hearing loss management, only 16 (12.7%) reported race/ethnicity, and over half 88 (69.8%) reported sex. Of the 16 studies that reported race/ethnicity, only 5 included > 30% non-white representation. Among the 88 manuscripts that reported sex, half (51.2%) reported > 45% female representation. While on average 80 study participants were included among observed studies, the median number of minority participants among studies that reported race/ethnicity was 9, and a median of 12 females were included among studies with a numerical breakdown by sex. On average, 41% (range 1.6% – 77.5%) of participants were female among studies that reported sex, and 30% (range 2.0% – 100%) of participants were minorities among the 16 studies reporting race/ethnicity. Reporting of race/ethnicity varied significantly by source of funding and journal type, while reporting by sex differed only by journal type.

Conclusions: Studies investigating hearing loss management do not adequately reflect the U.S. population. A closer examination of the inclusion of diverse adults in clinical research related to hearing health is critical to the identification and amelioration of hearing care disparities and provides the opportunity to contribute to the development of tailored interventions that address the needs of an increasingly diverse U.S. population.

Diverse Recruitment & Retention in Community-Engaged Research: Lessons from HEARS

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Objectives: Effective behavioral interventions and associated trials reflect the complexity and context of the communities with which they are tailored and the behaviors they seek to address. Community-engaged methodology can serve to capture these complexities and is an established approach within public health, particularly when focused on understanding and addressing health inequities. Within hearing care, significant disparities persist despite the highly prevalent nature of age-related hearing loss and relatively few hearing-related trials include representation of racial/ethnic minorities that reflects the diversity of the U.S. population. Novel approaches are needed to increase the diversity of participants within hearing-related research. Community-engaged research along with human-centered design offers a promising approach to increasing recruitment and retention within community-based hearing care trials. HEARS (Hearing health Equity through Accessible Research & Solutions) is a community-based randomized controlled trial (NCT03442296) that combines principles of community-engaged research along with human-centered design.

Design: The HEARS intervention is a community-delivered hearing care program for primarily low-income, minority older adults delivered by peer educators currently in a randomized controlled trial (RCT) in Baltimore, MD. The HEARS study incorporates community-engaged research, with a Community Advisory Board, and a

human-centered design practitioner embedded in the research team. The HEARS RCT examines change in community function as the primary outcome 3-months post-intervention as compared to a 3-month delayed treatment group and follows all participants 12-months post-intervention.

Results: Recruitment efforts took place over 18 months with an initial recruitment goal of 100 participants. Over 150 participants were randomized. Participants are older adults (aged 60 years and older) with at least a mild hearing loss based on better ear speech PTA ($\geq$ 25 dB HL) and significant communication difficulty (HHIE-S $\geq$8). The cohort (n=151) includes 43% (n=65) individuals who self-identify as Black or African American, 55.6% (n= 84) with a high school education or less, and 63.6% (n=96) with<$25,000 in annual household income. Efforts were executed in partnership with affordable senior housing organizations, senior centers, and social clubs. Recruitment materials, including flyers and posters, were designed collaboratively with the input of community representatives. Materials emphasized values and images prioritized by community representatives, including values such as vitality, empowerment, normalization of the use of amplification devices, and the inclusion of individuals who reflected the racial/ethnic composition of recruitment sites. Recruitment events included information sessions, pop-up events, and integration into existing events hosted by community partners that built trust and demonstrated an ongoing presence by the research team within community spaces. Retention efforts included routine follow-up calls, birthday cards, outreach to community organizations, care packages, and study-branded materials following each assessment timepoint.

Conclusions: The HEARS RCT represents one of the largest cohorts to-date of a community-based cohort of older adults with hearing loss with significant representation of African American and low-income older adults, individuals who have not traditionally been included in hearing-related trials. Community-engaged research, partnered with human-centered design, may offer critical approaches to increasing representation within hearing-related trials and, ultimately, the development of interventions responsive to the needs of a wider population of older adults.

Optimization of HEAR-QL for Adolescents in a Rural Alaskan Population
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Objectives: Hearing-related quality of life (QOL) is a key outcome of interest in adolescents with hearing loss (HL), and the Hearing Environments and Reflections on Quality of Life Measurement (HEAR-QL) is the only validated tool currently available to measure this. A shortened version of the tool may be more useful in clinical practice by simplifying administration and reducing noise in the resulting scores. We hypothesize that HEAR-QL can be optimized and shortened for clinical use and research in the adolescent population.

Design: The 28-item HEAR-QL questionnaire for adolescents ages 13 years and older, along with a 4-item addendum tailored to the local environment and culture, was administered in a cluster randomized trial in rural Alaska. A cross-sectional evaluation of enrollment questionnaires was utilized for this analysis. Audiometric evaluation and HEAR-QL administration were performed on the same day. Adolescents in the Bering Strait School District completed the HEAR-QL questionnaire electronically via tablet from October 2017 through March 2019, and audiometric evaluations were performed on each participating adolescent by an audiologist. Exploratory factor analysis (EFA) was used to model the covariance structure of the item responses; factor loading patterns and item communality estimate were used to select the most salient items that explained the

structure. Reduced versions of the questionnaire were compared to assess reliability (Cronbach‚Äôs alpha), as well as the strength of the relationship between questionnaire scores for both HL and middle ear disease using Pearson correlations, linear regression for continuous pure tone average, and logistic regression for binary HL and middle ear disease status.

Results: A total of 499 adolescents completed the questionnaire and addendum. Evaluation of the EFA model suggested a shortened version of the questionnaire had similar results, with scores from 7 items (factor loadings > 0.7, communality > 0.5), strongly correlating to scores from all 32 items (Pearson _= 0.94, R2 = 88.4%). Cronbach's alpha was slightly reduced but remained high (0.96 to 0.89). Correlation of scores with pure tone average increased in magnitude (Pearson _: -0.367 to -0.379; R2 = 12.6% to 14.1%). Area under the curve (AUC) for predicting HL was comparable (71.6% for all items, 70.2% for 7 items), but AUC was reduced for predicting middle ear disease (68.0% for all items, 63.8% for 7 items).

Conclusions: Our findings demonstrate that shortening the HEAR-QL questionnaire based on statistical criteria can produce scores that maintain a comparable relationship with measures of hearing loss in this population. This suggests the potential for creating a shortened instrument that is faster to administer in clinical practice without losing pertinent information. However, in general HEAR-QL scores had significant variability and noise in this rural Alaskan population, indicating the need for a more targeted QOL instrument to accurately measure hearing-related QOL in rural Alaska.

Optimizing the Assessment of Postural Stability and Fall Risk
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Objectives: The primary aim is to investigate whether personal limits of stability (pLOS) measured from healthy adults is different from the theoretical limits of stability (tLOS), and whether sensory organization test (SOT) equilibrium scores are significantly different when calculated based on pLOS instead of tLOS in healthy adults. The secondary aim is to determine if calculation of a personalized SOT (pSOT) based on the pLOS is an accurate marker for fall-risk in a group of TBI patients.

Design: 60 healthy volunteers were recruited into three age-groups: young (18-39), middle-aged (40-64), and elderly (65-80), with equal numbers of males and females. All had normal age-based hearing and a negative history of vertigo and imbalance. Postural stability testing included SOT and LOS. Additional measures of balance perception and mobility included the Activities-Specific Balance Confidence Scale (ABC) and the Timed-Up-and-Go (TUG) test. Additionally, 159 patients with TBI aged 18-86 years (M=44.5, SD=6.7) were evaluated using SOT and LOS. Medical records were reviewed for occurrence of falls in the succeeding 1-3 yrs. SOT scores derived using pLOS versus tLOS were compared to determine which method is more closely associated with the recorded falls history.

Results: The pLOS from the healthy volunteers (M=9.3, SD=1.3) was consistently and significantly lower than the tLOS across both sexes and all healthy age groups (t(59)= -18.32, p<.0005); however, no aging or sex effect was observed. Subsequently, SOT scores calculated using pLOS were significantly lower and evidenced more variability than scores using tLOS. TUG scores were a predictor for pLOS, however ABC scores did not

correlate with pLOS. The pLOS of the TBI group (M=7.7, SD=1.9) was significantly lower than that of the healthy cohort (t(104)= 7.12, p<.00050) and subsequently, pSOT scores were also lower. Further analysis of the sensitivity and specificity of pSOT in identifying fall-risk in the TBI patients is currently underway.

Conclusions: These findings suggest that use of tLOS in the calculation and interpretation of SOT may underestimate postural instability and may have implications for evaluation of fall-risk, particularly for groups with a pathologic reduction in LOS. We propose use of a personalized approach to the interpretation of SOT results.