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PODIUM ABSTRACTS

PODIUM SESSION I: AMPLIFICATION I

Impact of Service-Delivery Model and Hearing-Aid Technology on Patient Outcomes

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Objectives: Over-the-counter (OTC) hearing aids (HAs) have the potential to improve affordability and accessibility of hearing healthcare. Previous randomized control trials (RCTs) that investigated patient outcomes of OTC HAs and the associated services have found that although OTC HAs received lower satisfaction ratings compared to prescription HAs fitted by audiologists, they exhibited similar outcomes to prescription HAs across multiple domains such as communication abilities and hearing handicap. The present study aims to determine the effects of HA service-delivery model and technology, as well as their interaction, on patient outcomes.

Design: A two-site double-blinded RCT was conducted at the University of Iowa and Vanderbilt University Medical Center. Participants were randomly assigned to one of six parallel arms, which were factorial combinations of three service-delivery models-an audiologist-based model (AUD), an OTC model in which HA users took the full responsibility for learning and using OTC HAs, and a hybrid model in which audiologists provided streamlined services to fit OTC devices (OTC+)-and two levels of HA technology (high-end and low-end). To ensure better control of study variables, prescription HAs were used to simulate OTC HAs, and OTC and OTC+ services were provided by our labs. OTC HAs used a preset-based fitting method developed based on the audiometric data of a national health database. Patient outcomes were collected at 6-week post fitting using (1) the Glasgow Hearing Aid Benefit Profile (GHABP) questionnaire implemented as a smartphone-based in-situ self-report (Ecological Momentary Assessment; EMA), (2) retrospective questionnaires including the Satisfaction with Amplification for Daily Living (SADL), the Profile of Hearing Aid Benefit (PHAB), and the Handicap Inventory for the Elderly/Adults (HHIE/A), and (3) a lab-based speech recognition test.

Results: 247 older adults with mild-to-moderate hearing loss completed the study. The EMA GHABP data indicated that AUD participants reported longer HA use time than OTC+ patients. The EMA GHABP further indicated that, for patient outcomes averaged across four outcome domains (hearing aid benefit, residual handicap, residual disability, and hearing aid satisfaction) and four listening situations (TV listening, small conversation in quiet, conversation in noise, and group conversation), AUD participants reported better outcomes compared with OTC and OTC+ participants. No other effects, including HA technology and study site, and no interactions were found to be significant. Similar to the GHABP, AUD participants reported higher HA satisfaction in the SADL than OTC and OTC+. In contrast, the service-delivery model, HA technology, and their interaction did not have a significant effect on the PHAB, HHIE/A, and the speech recognition test.

Conclusions: The AUD model resulted in superior outcomes compared to the OTC and OTC+ models, with the difference evident only in EMA results and not reflected in retrospective questionnaires (excluding the SADL) or the lab-based speech recognition test. Neither the hybrid hearing aid fitting service nor advanced HA technology demonstrated improvements in patient outcomes. While this study suggests patients assigned to service-delivery models with more limited services than the AUD model had poorer outcomes, the limitations of an RCT for comparison across service models will also be discussed.

Patient Factor Predictors of Hearing Aid Service Level-Based Outcomes

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Objectives: Over-the-counter (OTC) hearing aids (HAs) have the potential to improve the affordability and accessibility of hearing healthcare. The over-arching purpose of this study was to characterize the outcomes of three different service-delivery models and two different hearing aid technology levels. The primary study outcomes, discussed separately, demonstrated significant differences across service delivery models. The aim of this presentation is to discuss patient specific predictive factors as they relate to outcomes within and across the service delivery models.

Design: This double-blinded randomized controlled trial evaluated 247 adults with mild-to-moderate hearing loss across three service level groups, at two different sites that differed geographically and by population density (University of Iowa, Vanderbilt University Medical Center). The levels of service included: 1) An OTC model which required participants to take full responsibility for learning and using amplification with the support of print and online materials modified for this project; 2) A hybrid, "OTC+" model which added basic evaluation, selection and orientation services provided by a professional; and, 3) An "AUD" model providing best practice, audiologist-based, professional hearing aid services. Participants in each group were randomized into one of two device groups: 1) An entry level hearing aid (features similar to current mid-level OTC devices); and, 2) A premium level hearing aid from the same manufacturer. All participants were blinded to all other service levels. In addition, device level was obscured by replacing device names in support and fitting materials with generic names. The hearing aids were configured to have four, fixed, frequency responses encompassing those appropriate for listeners with mild-to-moderate hearing loss (Wu et al., 2020) for the OTC and OTC+ intervention groups. Conversely, participants in the AUD arm were fitted to individualized prescriptive gain targets using probe microphone techniques. All participants were initially evaluated on a variety of personal characteristics and predictive variables including age, audiometric hearing loss, cognition, working memory, personality, quality of life, and locus of control. Hearing aid outcomes were assessed during and after a seven-week field trial including an Ecological Momentary Assessment (EMA) based delivery of the Glasgow Hearing Aid Benefit Profile (GHABP) delivered by smartphone during the seventh week of the trial.

Results: Analysis of the primary research question revealed that there were significant differences in self-reported hearing aid outcomes based on the level of service provided, irrespective of hearing aid technology level. Preliminary analysis of the predictive variables suggests many of the tested variable

were unrelated to the pattern of outcomes. However, other predictors, including global expectations as quantified by the Expected Consequences of Hearing Aid Ownership (EHCO), were significantly related to the measured pattern of outcomes. Current analyses are being conducted to examine the potential contribution of sub-factors within the predictive variables. This more detailed analysis of the predictive variables and their relationship to the overall study outcomes will be discussed.

Conclusions: Preliminary analyses suggests that service delivery dependent outcomes may relate to individual participant factors. These data have the potential to inform future studies, and current clinical practice, regarding the optimization of OTC and limited-service delivery models.

How Many Settings does an OTC Hearing Aid Need?

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Objectives: Over-the-counter hearing aids (OTCs) must allow users to choose a setting that provides good audibility while balancing sound quality preferences. One approach is to use a limited set of gain-frequency configuration presets that are designed so that a user could find a preferred setting from among them. Having more preset options could guarantee that a user could find a preferred setting but could mean a longer and more difficult self-fitting process. In this presentation, we describe a population-based approach to hearing aid preset design and an investigation into how many presets are required to allow users to arrive at a preferred hearing aid setting.

Design: Preset design: NAL-NL2 targets were calculated for audiograms representing the user population. These were used to design three sets (4, 16, and 32 presets) of gain-frequency configurations that could be appropriate for most users. Presets were designed using a genetic algorithm to find presets that would cover the maximum number of users for a given number of presets. The first set of presets (4 presets) could cover 82% and the second set (16 presets) could cover 97% of the user population within 5 dB of their NAL-NL2 targets. The third set considered both targets and the known preference variations of hearing aid users away from targets. A set of 32 presets was designed that could cover 80% of users within 5 dB of their targets or their preferred variation on targets. Experiment: the preferred preset was determined using blinded, double-elimination style tournaments. In the first phase, participants (N=30) completed concurrent double-elimination tournaments for all 3 sets of presets using A/B comparisons. Participants listened to the presets on an open-source hearing aid and toggled between 2 presets during a match before selecting their preferred preset. The winning preset moved on while the loser moved to the loser bracket. The winners from each set competed in a similar tournament along with the participant's NAL-NL2 target settings. An overall winner was found for speech in quiet and in noise. Speech perception and real-ear aided responses were performed for each preset winner and the NAL-NL2 fitting.

Results: Participants generally favored the 32-preset setting over the other settings. This was especially true for speech in noise. The 16-preset setting was the second-most preferred setting. NL2 was generally the least preferred setting. Despite users demonstrating clear preferences, no differences in speech

perception (in quiet or in noise) were observed between hearing aid settings. Although many users selected presets with similar gain-frequency configurations, some participants selected presets that differed considerably.

Conclusions: For OTCs to be effective and provide user satisfaction, settings need to account for user preferences. Hearing aids that use preset gain-frequency configurations need larger sets of presets than the typical 4 or 5 in order of users to find a preferred setting. The trade-off with a larger number of setting choices is that selection of a preferred preset can become challenging. However, using simple A/B comparisons in a tournament-style process is an efficient method with low cognitive load and simple graphical user interfaces.

Effects of Artificial-Intelligence-Based Noise Suppression on Intelligibility and Subjective Noise

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Objectives: Poor speech understanding in background noise is the primary auditory complaint of individuals with hearing loss. Many types of noise reduction have been shown to improve subjective aspects of noisy speech, but, unfortunately, improving speech understanding by reducing noise using a single-microphone algorithm has been extremely challenging. However, recent advances in artificial intelligence (AI) have finally made it possible for high-powered, laboratory-based deep-learning algorithms to improve the intelligibility of noisy speech for listeners with and without hearing loss. Although such algorithms provide impressive intelligibility benefits, today's consumer-grade devices (i.e., personal computers, smartphones, hearing aids, etc.) lack the computational power to run these laboratory-based algorithms in real time. More recently, a new generation of AI-powered noise-suppression applications have become available on consumer devices. Unlike large-scale laboratory-based models, these AI-based algorithms can operate on low-power devices and perform noise suppression in real time, but their capacity to improve speech intelligibility is unknown. The objective of this study was to evaluate five commercially available AI-based noise-suppression systems from Apple, Microsoft, Zoom, Nvidia, and Krisp on their ability to improve speech intelligibility and subjective noise mean opinion scores. A high-powered laboratory-based system served as a performance benchmark.

Design: In a balanced within-subjects design, 10 young adults with normal pure-tone hearing thresholds (ages 19-24 years) participated in the experiment. Each participant repeated 252 sentences presented at -5 dB signal-to-noise ratio in two types of background noise: speech-shaped noise and multi-talker babble. Sentences in both noise types were presented in seven processing conditions: unprocessed (noisy) and processed by six different AI-based noise-suppression systems (one high-performance benchmark algorithm and five commercially available applications). Participants also rated the intrusiveness of the noise in each sentence.

Results: Across processing conditions, intelligibility was higher in speech-shaped noise than in babble. The high-performance benchmark algorithm improved intelligibility by 13.4 and 23.7 percentage points in speech-shaped noise and babble, respectively. However, the five commercially available algorithms resulted in intelligibility decrements ranging from -15.4 to -51.7 percentage points. All six algorithms resulted in improved subjective noise mean opinion scores in both speech-shaped noise and babble, but the babble noise was rated as significantly more intrusive than the speech-shaped noise. The high-performance benchmark algorithm produced the highest subjective noise mean opinion scores. Several of

the other algorithms that produced the largest improvements to the subjective noise also displayed the largest intelligibility decrements.

Conclusions: The high-performance benchmark algorithm demonstrates that an AI-based noise-suppression system can improve both speech intelligibility and subjective noisiness. Although this result is encouraging, today's consumer-grade devices are not powerful enough to run this algorithm in real time. In contrast, the five commercially available noise-suppression applications, which run in real time on easily accessible personal computers and smartphones, actually made speech less intelligible. Although all of the algorithms that were tested improved subjective noisiness, advances in hardware and/or software technology are likely necessary before any of these algorithms can become clinically viable for improving speech understanding for individuals with hearing loss.

RHHI and Pure-Tone Average Predict Hearing Aid Use Equally Well

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Objectives: Knowledge of the predictive ability of self-reported versus audiometric hearing could inform decision-making related to protocols to determine hearing aid candidacy. This study aimed to (i) compare the Revised Hearing Handicap Inventory (RHHI), a measure of self-reported hearing difficulty, and pure-tone average (PTA) in their abilities to predict hearing aid use, and (ii) report the optimal cut point values for the RHHI and PTA that predict hearing aid use.

Design: Participants were from the MUSC Longitudinal Cohort Study of Age-Related Hearing Loss, an ongoing community-based cohort study (1988-current). Participants were included in this study if they had complete RHHI and PTA data from at least two examinations and, for hearing aid users only, had complete data on the year they acquired hearing aids. Participants who were hearing aid users at baseline were excluded. We evaluated the ability of the RHHI and PTA as (i) continuous variables, and (ii) binary variables characterized by the optimal cut point determined by the Youden Index to predict hearing aid use. The Youden Index is used to determine cut point values by selecting the optimal cut point where sensitivity and specificity are equally important. RHHI scores range from 0 to 72, and PTA was defined as averaged thresholds at frequencies 0.5, 1.0, 2.0, and 4.0 kHz in the worse ear. Hearing aid use was defined as self-reported successful hearing aid use and/or hearing aid use at least twice per week. We used logistic regression models and receiver operating characteristic (ROC) curves with corresponding concordance statistics (c-statistics) and 95% confidence intervals (CIs) to determine the predictive ability of models, and chi-square tests to determine whether c-statistics were significantly different.

Results: This study included 581 participants with a mean age of 72.9 (SD 9.9) years; 59.9% were female and 14.3% were Minority race. The number of hearing aid users was 121 (20.8%). The c-statistics for the RHHI (0.79 [95% CI 0.75, 0.83]) and PTA (0.81 [95% CI 0.78, 0.85]), as continuous variables, were not significantly different (p=0.25). The optimal cut points for the RHHI and PTA to predict hearing aid use were 6 points and 32.5 dB HL, respectively. The c-statistics for the RHHI (0.72 [95% CI 0.68, 0.76]) and PTA (0.75 [95% CI 0.71, 0.79]), as binary variables, were not significantly different (p=0.27).

Conclusions: The RHHI, a measure of self-reported hearing difficulty, has similar ability to PTA to predict hearing aid use. Given that the RHHI is a simple, low-cost, and practical tool that evaluates individuals' perceived hearing, it may be possible to utilize the RHHI to predict hearing aid use in settings where audiometry is not feasible, such as hearing loss screening programs that aim to identify individuals who may benefit from treatment for

Impact of Alignment Delay on Assistive Listening in Large Venues

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Objectives: The study's objective was to characterize the impact of alignment delay between an assistive listening audio signal and an acoustic audio signal produced by loudspeakers in large auditoriums. The study assessed how such delays affect speech-in-noise comprehension, subjective comprehension confidence, and perceived listening effort among listeners with normative hearing. By examining these factors, the study aimed to provide insights into auditory processing challenges in public spaces and to suggest potential improvements for assistive listening technology.

Design: The study simulated listening to an assistive listening system with an open-fit hearing device in a large auditorium using a modified version of the QuickSIN test. 53 participants were exposed to a speech signal combined with four-talker babble noise, presented at varying signal-to-noise ratios and alignment delays. The alignment delay was introduced between two superimposed identical copies of the speech signal to replicate the echo effect that listeners experience when seated at a large distance (>35 ft) from the loudspeakers.

Results: The study identified a significant and progressive impact of alignment delay on speech-in-noise comprehension. Increases in delay led to a corresponding rise in the SNR-50 score, indicating a decline in comprehension. Specifically, even moderate delays of around 70 ms resulted in an average SNR-50 increase of more than 3 dB, with an increasing impact for longer delays. Additionally, alignment delay consistently showed a negative impact on comprehension confidence and listening effort, particularly at signal-to-noise ratios between 8 and 12 dB.

Conclusions: The study underscores the critical importance of accounting for and compensating alignment delay in the design of assistive listening systems to maximize speech comprehension and confidence, while minimizing listening effort. The findings suggest that even moderate alignment delays can significantly impair speech understanding in environments such as large auditoriums. While this study focused on participants with normative hearing, the implications are particularly pertinent for individuals with hearing disabilities, who are likely to experience even greater challenges. These insights highlight the need for careful consideration of auditory signal timing in the architectural design of public spaces and the technological development of assistive listening devices. The study advocates for enhanced standards in assistive listening system design to ensure auditory accessibility and comfort for all audience members, particularly those with hearing disabilities.

PODIUM SESSION II: COCHLEAR IMPLANTS

Evaluation of Need for Annual Cochlear Implant Appointments via App-Based Self-Assessments

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Objectives: Cochlear implant follow-up appointments are important to recipient outcomes. This is particularly important during the first year following activation of the device. Our traditional follow-up schedule has patients returning to the clinic 6-7 times in the first year following activation, twice the second year, and annually thereafter. The decrease in return visits occurs because patient performance and changes in psychophysical measurements plateau. Annual appointments consist of patient report regarding performance and potential concerns, audiological testing including threshold detection and speech perception testing to monitor performance, internal device monitoring and programming adjustments as needed. Patients who report stable hearing and demonstrate consistent scores on performance measures often have minimal or no programming changes during these visits. Annual trips to the clinic can be a burden for patients, particularly due to distance, time required for the travel, finances, and the need for assistance from family or friends. Use of mobile applications to conduct remote, self-administered testing could negate the need for an annual visit when cochlear implant benefit and test outcomes are determined to be stable. The primary objective of this study is to determine whether the results from self-administered performance measures can be used by clinicians to determine the need for annual in-person clinic visits.

Design: Fifteen cochlear implant recipients were drawn from the adult clinical population during routine clinical care. Subjects had at least 12 months cochlear implant experience and clinician knowledge of good audibility. Subjects used a specific, Bluetooth-capable sound processor, had experience with an iOS-compatible device and could understand, read and respond in English. Subjects completed self-assessments consisting of a hearing screener (at 30 dB HL), speech perception tasks, and questionnaires administered via a mobile app within 2 weeks prior to their annual clinic visit. Results from the self-assessments were reviewed by a clinical audiologist who determined the need for the routine visit. All patients then completed the scheduled visit. Following this visit, both the subject and audiologist completed questionnaires to assess attitudes toward remote monitoring and utility of incorporation of the remote assessments into clinical practice.

Results: In 10 out of 15 cases, the audiologist's decision on the need for an annual appointment, based on review of the self-assessment results, did not change after seeing the participant for their clinical visit. When audiologists did change their opinion on the need of the clinic visit, it was either 1) because the patient indicated they wanted to see their clinician, but,ÄØneither the remote monitoring or clinic visit results indicated there were any issues, or 2) because changes in audibility were not picked up by the hearing screener in the app. Patients and professionals indicated potential benefits in incorporating remote assessments into clinical routine and provided feedback on potential improvements.

Conclusions: Favorable performance test results and subjective ratings of benefit and hearing performance as measured using a remote monitoring mobile application may provide sufficient evidence for a hearing care professional to determine when a recipient can defer a routine follow-up appointment or when intervention is required via an on-site follow-up visit.

For Some Cochlear-Implant Users, One Ear Can Interfere with the Other

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Objectives: Bilateral cochlear implants (BI-CIs) and single-sided-deafness CIs (SSD-CIs, one normal-hearing and one CI ear) provide clear spatial-hearing benefits but with large outcome variability. One possible contributing factor is tremendous variability in across-ear integration ability to facilitate the perceptual separation of concurrent speech, as revealed by a "contralateral unmasking" paradigm. In the monaural condition, target and interfering speech are presented to one ear. In the bilateral condition, a copy of the interfering speech is also presented to the other ear. In some cases, the contralateral copy of interfering speech modestly improves target-speech understanding ("unmasking"). In other cases, it reduces performance ("interference"), sometimes dramatically. This series of studies aimed to understand the factors underlying this enormous range-from unmasking to interference-across BI-CI and SSD-CI listeners.

Design: Experiment 1 assessed the extent to which monaural-performance asymmetries account for interference or unmasking magnitude. Unmasking or interference were compared to monaural speech-in-quiet scores for 25 BI-CI listeners with a large range of asymmetry. Experiment 2 tested whether interference reflects poor binaural fusion of the bilaterally presented interferer. Interference was assessed when a second interfering talker was added to the contralateral ear (multi-masker condition) instead of a copy of the first interfering talker (contralateral unmasking condition). Six BI-CI users, 5 SSD-CI users, and 6 normal-hearing (NH) listeners have been tested to date. Experiment 3 examined if SSD-CI contralateral interference reflects a general selective-attention deficit independent of long-term asymmetric-hearing experience. Contralateral interference for 28 NH listeners presented with SSD-CI vocoder simulations was compared to non-vocoded monaural speech understanding in competing speech. The NH listeners had a wide range of ages for comparison with a group of 11 SSD-CI users.

Results: In Experiment 1, 74% (37/50) of the BI-CI ears tested showed interference instead of unmasking. While interference and monaural speech-understanding asymmetry were correlated, there was nevertheless a large range of interference even across listeners with similar asymmetry. In Experiment 2, interference magnitude for the multi-masker and contralateral-interference conditions was correlated, pointing to a role for poor binaural fusion. However, purely dichotic-listening performance also correlated with interference magnitude, suggesting a role for selective-attention deficits unrelated to fusion. In Experiment 3, NH-vocoder contralateral interference and performance in a monaural, non-vocoded competing-speech task were strongly related. Interference magnitude for NH-vocoder listeners with no asymmetry history was indistinguishable from that for SSD-CI listeners with long-standing asymmetry.

Conclusions: While there is some evidence that contralateral speech interference reflects the degree of interaural asymmetry, there are other important mechanisms at play. One possible contributor is poor binaural fusion associated with CI listening, leading to extra perceived voices in a mixture. Selective-attention deficits that are age-related, rather than reflecting maladaptive central plasticity from asymmetric listening experience, likely also play a critical role. Therefore, BI-CI and SSD-CI users might benefit from auditory training in selective-attention tasks. [Funding: NIH-NIDCD R01-DC-020506. The

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Assessing Test-Retest Reliability of Retrofittable Compact Speaker Arrays

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Objectives: Current clinical equipment for spatial-hearing assessment is limited, primarily relying on headphones, a non-standardized set of two loudspeakers, or in some facilities, a custom-designed speaker-array arrangement. Headphone-simulated spatial hearing cannot be used with ear-level devices, and across-clinic variation in loudspeaker configurations further impedes outcome comparisons. Through Small Business Innovation Research (SBIR) grants, the Department of Defense (DoD) supported the development of two different compact speaker-array systems meeting specified criteria for clinical use. The systems are in the process of being deployed to several DoD/VA clinics. This study aimed to validate the speaker-array systems for spatial-hearing testing by assessing the test-retest reliability within and across speaker array types for two spatial-hearing tasks.

Design: Array 1 comprises seven speakers (0, ±15, ±30, and ±60° azimuth) with a satellite speaker placed 180° behind the participant. Array 2 comprises eight speakers positioned uniformly around the subject's head with 45° spacing . Test stimuli and protocols were loaded onto an Android tablet and connected to each speaker array via cable. Inclusion criteria were broad to obtain a large range of spatial-hearing performance. At the time of abstract submission, 21 subjects had participated: 15 normal-hearing, 5 cochlear-implant (CI) users (3 bimodal, 1 bilateral, 1 unilateral) and 1 bilateral hearing-aid (HA) user. Normal-hearing subjects were tested monaurally (earplug in the right ear) and binaurally (unoccluded). CI subjects were tested monaurally (poorer ear only) by removing one CI or binaurally (both ears), except for the unilateral CI user (monaurally only). The HA listener was tested with the right HA only or both HAs. Task 1: Subjects localized spectral- and level-roved broadband stimuli presented from a single speaker chosen at random. Task 2: Speech-reception thresholds (SRTs) were measured adaptively using a modified version of the Oldenburg Sentence Test. The speech was presented from 60° or 90° to the poorer-hearing (or plugged) side and the noise presented symmetrically from the other side. Data collection was blocked by speaker array prototype, listening condition, and hearing task. Order within each block was randomized. Test-retest reliability and inter-array agreement were both assessed using the Intraclass Correlation Coefficient (ICC) statistic.

Results: For both speech in noise (SRT, in dB) and localization (mean absolute error, in degrees azimuth), two-way mixed-effects models assessed the agreement between the two test blocks (retest) or between arrays. Speech in noise showed excellent test-retest (ICC=0.92) and inter-array (ICC=0.95) reliability. Localization showed good test-retest reliability (ICC=0.86), but only moderate inter-array reliability (ICC=0.64).

Conclusions: Speech-in-noise tests showed a high degree of agreement between speaker arrays, likely because this test involving two loudspeakers was similar between the two arrays. Localization showed only moderate agreement between the two arrays, likely reflecting the substantial differences in speaker arrangement. Overall, these results suggest that either array should produce reliable estimates of spatial-hearing ability that could be used to track performance longitudinally (for clinical or research purposes) or cross-sectionally (for research purposes). Future work will examine effects of room characteristics (room size, array placement within the room, and sound treatment) to provide additional insights into array reliability.

Emotional Responses to Non-Speech Sounds in Cochlear Implant Users

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Objectives: Adults with hearing loss demonstrate a reduced range of emotion in response to non-speech sounds and pictures compared to their peers with normal hearing. This reduced range of emotional responses has important implications for psychosocial functioning and overall well-being, as a broad range of emotions is natural in daily life. Unpleasant emotions serve to activate a person to encourage action (e.g., in response to a crying baby), while pleasant emotions serve to broaden attention and facilitate stress recovery (e.g., in response to pleasant, calming music). Reduced emotional responses to sounds have been linked to reduced social participation and could have an impact on mental health. Previous studies have primarily focused on emotional responses to non-speech sounds. The purpose of this study is to investigate if group differences in emotional responses to sounds are also evident when sounds are paired with semantically related pictures (e.g., the sound of a crying baby and a picture of a sad baby) or when pictures are presented in isolation.

Design: Adults in three different listener groups (normal hearing in both ears, hearing aid candidates with sensorineural hearing loss in both ears or cochlear implant users with one or two implants) provided ratings of valence and arousal in response to non-speech sounds and/or pictures. Valence and arousal reflect the two most common dimensions of emotion perception and represent the degree to which an emotion is pleasant/unpleasant (hedonistic valence) and the degree of activation of that emotion (arousal). Stimuli were presented in quiet for 1.5 seconds using a computer screen and a loudspeaker in front of the participant at a moderate level.

Results: Linear mixed effects modeling was used to analyze the data. Specifically, ratings of valence or arousal were the dependent variables and the fixed factors were condition (auditory-only, visual-only, and auditory-visual), stimulus category (pleasant, neutral, unpleasant), and group (normal hearing, hearing aid candidates, cochlear implant users). Results revealed group differences were primarily in the auditory-only condition; people with hearing loss provided similar ratings to their peers with normal hearing in response to pictures.

Conclusions: Adults with hearing loss, even while using cochlear implants, demonstrate a reduced range of emotional responses to sounds. The group differences are smaller or disappear when visual stimuli are included. In addition, people with hearing loss do not demonstrate disrupted emotion perception of

pictures, suggesting hearing loss is only related to disrupted emotion perception of sounds. These results suggest that, under multisensory conditions, adults with hearing loss might not be disadvantaged in terms of emotion perception.

Vocal Mimicry Illustrates Perception of Prosody through a Cochlear Implant

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Objectives: Prosodic features of speech - particularly pitch contour - are notoriously difficult to transmit through a cochlear implant (CI) and also difficult to quantify in perception tasks. Most work has been done using discrimination or identification of simple stimuli that bear little resemblance to the content of actual speech sounds. We developed a new vocal mimicry task in which a listener reproduces the pitch contour of a real utterance. The listener's own production serves as a proxy measure of their perception. We use this technique to explore how fundamental frequency (F0) contours and other attributes of prosody are delivered through a CI. Previous results suggested CIs could only transmit F0s lower than 300 Hz. However, the stimuli were natural vocalizations with differing emotions making it difficult to pin down the exact perceptual contributions and limitations. In response to this ambiguity, the current study followed up with a variety of conditions that were carefully designed to test a potential F0 limit and related aspects of pitch contour perception.

Design: Naturally spoken stimuli were manipulated using the PSOLA algorithm in Praat to tightly control variations in F0, allowing a straightforward interpretation of prosody perception. Stimuli were played via a direct audio link into the CI of single-sided deaf cochlear implant (SSD-CI) users, whose typical-hearing ear could be used to examine the influence of the CI while controlling for the individual ability to mimic accurately. Their own voice was audible only through the typical-hearing ear. Participants mimicked the sentence that they heard, including all perceptible aspects of pitch, tone, speed, and inflection. The task was repeated for stimuli presented only to the typical-hearing ear to control for the individual ability to mimic prosody accurately. Stimulus manipulations included compression and/or expansion of the F0 contours, allowing analysis of perceived direction and absolute and relative magnitudes of F0 contours. F0 range varied across stimuli to test whether performance was different for contours that extended above 300 Hz. Additional manipulations explore the timing and speed of F0 changes at targeted words. F0 contours were extracted from recordings of the vocal mimicry for both the implanted and acoustic ears.

Results: Based on pilot data, F0 contours are well reproduced through a CI and acoustic hearing when F0 is below 300 Hz. The absolute mimicked F0 differs from the original due to limitations in vocal abilities (e.g., the ability of a woman to imitate a man) but relative changes in F0 are accurate in direction and relative magnitude. Mimicked F0 contours for stimuli above 300 Hz are accurate for the acoustic ear but severely compressed or entirely inaccurate for the CI ear. Audio demos provide insight into qualitative differences between listening through an acoustic and implanted ear.

Conclusions: The quality of prosody perception through a CI is inconsistent across different F0s. An accurate representation of F0 only below 300 Hz suggests that listeners are using temporal cues for F0

contour representation. Improving temporal coding (both signal processing and ability of the auditory system to track temporal coding) might enhance prosody perception.

Neurocognitive Contributions to the Recognition of Spectrally Degraded Speech

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Objectives: When listening to speech under adverse conditions, listeners compensate using neurocognitive resources. These compensatory mechanisms include crystallized intelligence, fluid intelligence, working memory capacity, inhibition-concentration, and information processing speed. A clinically relevant form of adverse listening condition in adults with moderate-to-profound hearing loss is listening through a cochlear implant (CI), which provides a highly spectrally degraded speech signal. From a research standpoint, CI processing is often simulated using noise-vocoding in normal-hearing (NH) listeners. However, it is unclear whether the neurocognitive mechanisms supporting degraded speech recognition are the same in both groups. This study investigated the neurocognitive mechanisms that support recognition of spectrally degraded speech in adult CI users and NH peers listening to noise-vocoded speech. Listeners were tested using a range of linguistic materials to test the hypothesis that neurocognitive functions would contribute to spectrally degraded speech recognition across different measures. A second hypothesis was that an overlapping set of neurocognitive functions would contribute to recognizing noise-vocoded speech in NH adults as compared with clear speech in CI listeners.

Design: Ninety-three adults with either a CI (53 CI individuals) or age-normal hearing (40 NH individuals) participated. Participants were tested for recognition accuracy for speech materials that varied in linguistic and acoustic content, in the clear for CI users and after 8-channel noise-vocoding for NH participants. Materials consisted of a set of isolated words (CID W22), semantically meaningful sentences (Harvard Standard), sentences that were syntactically appropriate but semantically anomalous (Harvard Anomalous), high-variability sentences spoken by different talkers (Perceptually Robust English Sentence Test Open-set, PRESTO), and audiovisually (AV) presented sentences (City University of New York, CUNY). A battery of neurocognitive tests assessed vocabulary knowledge, fluid intelligence, working memory capacity, inhibition-concentration, and speed of lexical and phonological access. Separate multivariable linear regression analyses with robust standard errors were performed for each speech recognition task to assess the contributions of each neurocognitive function in each group using interactions, while adjusting for age and socioeconomic status where appropriate.

Results: Performance on all five speech recognition tasks was associated with neurocognitive functions for at least one group. Fluid intelligence contributed significantly (or demonstrated a trend towards significance) to recognition accuracy for isolated words, meaningful and anomalous sentences, and high-variability sentences for both groups. Speed of lexical access contributed to performance on most speech recognition tasks for CI users but not for NH peers. Finally, inhibition-concentration, speed of phonological access, and vocabulary knowledge contributed to AV sentence recognition in NH listeners, while no neurocognitive functions contributed to AV sentence recognition in CI users.

Conclusions: Neurocognitive functions contribute to recognition of speech in both CI users and NH individuals listening to noise-vocoded speech. Fluid intelligence contributes broadly to performance on most speech recognition tasks for both CI users and NH listeners, while speed of lexical access

contributes only in CI users. Findings suggest that the complexity of the speech materials used during testing determines the particular contributions of neurocognitive skills to speech recognition, and that NH processing of noise-vocoded speech does not represent CI processing of speech.

PODIUM SESSION III: HEARING & RISKS

Associations of Multisensory Impairment with Cognitive Impairment and Dementia

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Objectives: Sensory impairments frequently co-occur in older adults, with an estimated two in three older adults in the United States having at least two co-occurring sensory impairments (impairment to hearing, vision, olfaction, taste, and touch). However, sensory impairments are typically studied independently when investigating associations with cognition, with few studies accounting for their co-occurrence. Characterizing the combined impact of a multisensory phenotype on dementia could help elucidate a potential mode of pathogenesis. In this study, we investigated the cross-sectional association between multisensory impairment and cognitive impairment, and four-year longitudinal associations with incident dementia, in community-dwelling older adults. We hypothesized multisensory impairment is associated with an increased prevalence of cognitive impairment, and increased risk of four-year incident dementia, relative to no impairments.

Design: We used data from the Atherosclerosis Risk in Communities (ARIC) study, a longitudinal, community-based cohort study of adults enrolled from four US communities at baseline (visit 1, 1987-1989). We included all older adults that received hearing, vision, olfaction, and peripheral nerve function assessments, introduced at ARIC visit 6 (2016-2017). We excluded those with dementia at or before baseline (analytic sample, n=1,016). Follow-up occurred from ARIC visit 6 through visit 8 (2019-2020). We defined multisensory impairment (co-occurring, objectively-measured hearing loss [pure-tone average ≥25 dB], vision loss [presenting distance acuity >0.3 logMAR], anosmia [Sniffin' Sticks test score ≤6], and peripheral nerve damage [≥1 insensate site on left or right foot]) at baseline by number of impairments (0 [reference], one impairment, two impairments, three or four impairments). Prevalent cognitive impairment (mild cognitive impairment [MCI] or dementia) was classified by a neuropsychological test battery at the study baseline clinic visit. Four-year incident dementia was classified by neuropsychological test battery performance, as well as individual- and proxy-level questionnaires outside clinic visits, and claims data from hospitalizations and death certificates. We estimated multivariable-adjusted prevalence ratios (PRs) of MCI/dementia and hazard ratios (HRs) of incident dementia by multisensory category using Poisson models with robust variance and Cox proportional hazards models, respectively.

Results: Among eligible participants (age range: 71-93 years, 62% female, 41% Black race), 27% had two co-occurring sensory impairments, and 11% had three or four impairments. As expected, hearing loss

was the most common sensory impairment; among those with two or more impairments, 89% had hearing loss. There were 45 cases of incident dementia over four years of follow-up. Multisensory impairment was associated with increased prevalence of baseline MCI/dementia (one impairment, PR: 1.13 [95% CI: 0.68-1.88]; two, PR: 1.84 [95% CI: 1.10-3.07]; three or four, PR: 2.68 [95% CI: 1.51-4.75]; P-trend:<.001). In the longitudinal analysis, multisensory impairment was associated with an increased risk of incident dementia (one impairment, HR: 1.83 [95% CI: 0.65-5.16]; two, HR: 2.19 [95% CI: 0.74-6.45]; three or four, HR: 5.40 [95% CI: 1.80-6.45]; P-trend: .002).

Conclusions: Multisensory impairment is common older adults. Our findings suggest multiple concurrent sensory impairments contribute additively to greater MCI/dementia prevalence and incident dementia, signaling the importance of considering multiple impairments together in studies of the contribution of sensory losses to dementia.

Audibility Index and Associations with Dementia in the ARIC Study

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Objectives: Dementia is a public health concern, with the prevalence projected to triple worldwide by 2050. One potentially modifiable risk factor for dementia is hearing loss (HL), with recent randomized trial evidence suggesting hearing treatment may benefit some older adults. Current epidemiologic studies of HL and dementia often rely on speech-frequency pure tone averages (PTA) to define HL; however, this does not necessarily capture clinically relevant data such as potential access to speech (i.e., shape of the audiogram). One easily calculable measure that does is the audibility index (AI), which uses pure tone thresholds and weights frequencies to predict audibility. Because the AI uses equivalent information to PTAs, it can routinely be collected from hearing assessments in large studies with limited time. Whether the AI, which should convey more information than PTA, better predicts functional outcomes in older adults is unknown. In this study, we investigated the criterion and construct validity of the AI by quantifying associations with incident dementia and compared it with other hearing measures we expect to be correlated.

Design: The Atherosclerosis Risk in Communities (ARIC) study is a longitudinal cohort study that recruited adults aged 45-64 (n=15,792) from four communities in the US in 1987-1989. We used audiometric thresholds (0.5-8.0 kHz), neurocognitive measures, and covariate data from ARIC visit 6 (2016-2017; analytic sample, n=2,992). The better hearing ear AI (bAI) was calculated based on five frequencies (0.25, 0.5, 1, 2, 4 kHz) and modeled categorically in tertiles. The better-ear PTA (bPTA) was calculated based on four speech frequencies (0.5, 1, 2, 4 kHz). Incident dementia was defined using a

standardized algorithm incorporating expert adjudication. We used Cox proportional hazards models to estimate hazard ratios (HR) of dementia by bAI tertile and by bPTA tertile. Correlations between the bAI and other hearing measures (bPTA, better-ear self-report) were explored graphically.

Results: Among eligible participants (mean age: 74.9 years [range=72-94 years]), relative to the highest tertiles, participants in the lowest bAI tertile were more likely to be older (mean, 76.8 years), male (51.9%), and report hearing aid use (49.1%). Over a median follow-up of 6.6 years, there were 362 incident dementia cases. HL defined by bAI was associated with an increased risk of dementia (second tertile, HR=1.48 [95% CI: 1.13-1.93]; lowest, HR=1.59 [95% CI: 1.21=2.09]). The magnitude of the association with dementia was similar when HL was defined by bPTA tertile (second tertile, HR=1.37 [95% CI: 1.05-1.79]; highest, HR=1.59 [95% CI: 1.21-2.08]). The bAI demonstrated strong correlation with the bPTA, and weak associations with better-ear self-report.

Conclusions: In a community-based cohort of older adults, HL defined by AI was associated with increased risk of dementia. Inferences were consistent when HL was defined by similar PTA thresholds, likely because AI and PTA were highly correlated. This indicates that the AI derives similar value to PTA while considering potential functional impacts of HL that PTA does not, supporting the use of AI in epidemiologic studies.

Sensory and Motor Functions Improve Predictions of Neurodegenerative Biomarker Positivity

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Objectives: Alzheimer's disease (AD) and related dementias have a long preclinical phase with pathological and neurodegenerative changes often decades before symptom onset. Early detection of high-risk individuals in midlife has great potential for future targeted treatments and preventions. Researchers developed risk scores such as the Cardiovascular Risk Factors, Aging, and Incidence of Dementia Score (CAIDE) and the Framingham Risk Score (FRS) and utilized them for dementia predictions. Sensory (hearing,vision,olfaction) and motor changes are common in aging adults and have been associated with increased risk of development of cognitive impairment, dementia, and AD. However, studies on the predictive value of sensory and motor function for early neurodegenerative changes are limited. This study aimed to assess whether midlife sensory and motor function can improve risk prediction of 10-year incidence of positivity in blood-based biomarkers of neurodegeneration and AD when added to prediction models using the CAIDE or FRS.

Design: We assessed sensory and motor functions and serum amyloid beta (Aβ42/Aβ40) and neurofilament light chain (NfL) levels at baseline, 5-year, and 10-year follow-ups in Beaver Dam Offspring Study participants(N=1529). NfL positivity (NfL+) was defined by a value in the age-specific 97.5%ile and amyloid positivity (A+) by Aβ42/Aβ40<0.051 (2 standard deviations below levels measured in normal controls from a separate study on AD). Hearing impairment was determined using pure-tone audiometry (PTA0.5-4kHZ>25 in the worse ear), vision impairment using the Pelli-Robson contrast sensitivity letter chart (log score<1.55 in the worse eye), olfactory impairment using the San Diego Odor Identification Test (<6 of 8 odorants correct), and motor function using the grooved pegboard test, grip strength, and self-report. We calculated the CAIDE and FRS using baseline health data. We assessed whether including baseline sensory (hearing,vision,olfactory) impairments and motor function improves CAIDE or FRS predictions of 10-year NfL+ and A+ incidence determined by the area under the receiver operating characteristics curves (AUROC) using logistic regressions.

Results: Individuals were on average 49(SD=9) years old at baseline;54% were women. Over the 10-year follow-up, there were N=71 A+ and N=115 NfL+ incident cases. Adding sensory and motor measures to CAIDE-only and FRS-only models significantly improved NfL+ (CAIDE AUROC increase: 0.61 to 0.69,p=.005; FRS AUROC increase: 0.63 to 0.70,p=.045) and A+ (CAIDE AUROC increase: 0.54 to 0.71,p=.04; FRS AUROC increase: 0.53 to 0.69;p=.09) predictions in adults above the age of 55. AUROC improvements were slightly smaller in the whole cohort and a trend only for some predictions.

Conclusions: Adding sensory and motor function to established dementia risk scores improved risk predictions of 10-year incidence of biomarker positivity in amyloid and NfL in individuals 55 years and older at baseline. This adds to existing research using cardiovascular assessments to predict dementia, demonstrating that hearing, vision, olfaction and motor functions may add relevant information to risk prediction models of biologically determined early changes along the AD and neurodegeneration spectrum. Importantly, sensory and motor functions can be assessed reliably, non-invasively and inexpensively. They could thus become practical additions for future prediction models to identify individuals at high-risk for developing AD and related dementias to target interventions and preventions.

Hearing Loss and Loneliness in Older Adults: Proposing Explanatory Factors

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Objectives: Understanding the relationship between hearing loss (HL) and loneliness in older populations may help improve assessment strategies and intervention efficacy. There is a paucity of evidence identifying potentially relevant factors beyond individual-level demographic characteristics for supporting a multilevel public health response. The current study completed three aims: (1) To examine the cross-sectional association at a population-level of audiometrically-confirmed HL and loneliness, and the joint association of HL with self-reported hearing handicap on loneliness; (2) To describe qualitatively the lived experiences of HL, hearing handicap, and loneliness among older adults across multilevel domains; and (3) To construct a joint display through integrating findings from aims 1-2 for proposing explanatory factors in the observed relationship. For aim 1, we hypothesized that HL is significantly associated with loneliness and that older adults with joint effects demonstrate higher odds of loneliness.

Design: We completed our investigation through a sequential explanatory mixed methods study design. We analyzed cross-sectional, population-based, observational data from N=2,527 older community-

dwelling participants enrolled in the Atherosclerosis Risks in Communities (ARIC) study to quantify estimates of the respective association and joint associations. We then purposively sampled and recruited N=10 older community-dwelling informants from the Hearing health Equity through Accessible Research and Solutions (HEARS) RCT for theoretically-guided, semi-structured descriptive interviews and thematic analysis. Integration involved constructing a themes-by-statistics visual joint display to identify remarkable thematic patterns for proposing an explanation underlying the observed relationship between HL and loneliness among community-dwelling older adults.

Results: In fully adjusted models we observed that compared to participants with typical hearing and no hearing handicap (referent), participants with moderate-to-severe HL overall had 49% significantly higher odds of loneliness (95% CI: 1.06, 2.11). Participants with HL of any severity level (mild or moderate-to-severe) and hearing handicap demonstrated up to 95% higher odds of loneliness than the referent (95% CI: 1.33, 2.86). Thematic analyses from interviews synthesized an expanded, multilevel model of potential contributors in the relationship between HL and loneliness with six novel conceptual domains identified. Integrative analyses revealed distinct patterns of perspectives and lived experiences with HL and loneliness across narrative data along hearing handicap status.

Conclusions: There is a fundamental distinction between physiologic (e.g., pure tone audiometry) and functional measures of hearing (e.g., self-reported hearing handicap). Older adults with HL who also experienced hearing handicap had up to 95% higher odds of loneliness at a population-level than their counterparts with typical hearing and communication function. We identified through narrative data a select number of descriptive themes arranged across a novel, expanded model with multilevel domains (e.g., social-structural conditions, social network conditions, and individual-level conditions). Data integration revealed that community-dwelling older adults with HL have inherently diverse perspectives and lived experiences with loneliness across multiple levels that is at least partially observed along differences in their respective hearing handicap statuses. Future public health strategies should remain adaptive in their respective designs for targeting a highly subjective condition like loneliness among older adults with HL.

Improving Speech Cue Audibility for Adults with Profound Hearing Loss

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Objectives: Loudness recruitment in the presence of a profound hearing loss can result in such a small residual dynamic range that a large amount of compression is required to provide audibility without causing loudness discomfort. The result can be diminished speech cues, such as variations in speech envelope, especially at soft input levels. It is important that people with profound hearing loss have access to soft sounds to maximize speech understanding in challenging listening situations that occur in everyday life, for instance, listening to someone from an adjacent room and understanding soft-spoken individuals like children. This paper reports the initial findings for a hearing aid algorithm, which only activates in very quiet environments to add gain to soft inputs The resulting improvements in speech intelligibility and listening effort will be reported.

Design: The study included 16 Mandarin-speaking participants with a profound hearing loss (4 frequency average of 85dBHL). The design was a single blinded, randomized laboratory based study using within-subject repeated measures. Objective speech intelligibility was measured as a percentage score when target stimuli were presented 4 meters in front. Subjectively perceived listening effort was assessed on a categorical scale with 14 steps, after the presentation of target stimuli at each of three distances (2 meters, 4 meters, and 8 meters). All measurements were carried out in a quiet meeting room with a noise floor of 32dBA.

Results: For distant speech in a quiet meeting room, the additional gain resulted in an increase in speech intelligibility of 22.1% ($p<0.001$), and significantly less subjective listening effort of 3.2 effort scale categorical units (ESCU) at 2 meters, 4.5 ESCU at 4 meters, and 5.4 ESCU at 8 meters ($p<0.001$)

Conclusions: For adults with profound hearing loss, adding gain to soft inputs only in quiet environments, resulted in improved speech understanding and listening effort. Anecdotally profound hearing loss results in frequent startles, when an approaching person is not heard. The results of this study indicated more than merely increased detection of soft speech (or an approaching person). The results exceeded this by demonstrating restored speech cues which would otherwise be lost.

The Effect of High-Frequency Spectral Cues on Monaural Spatial Hearing

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Objectives: Monaural spatial hearing abilities may be adversely affected by loss of high-frequency spectral cues. This study aimed to investigate the effects of extended high frequency hearing on localization performance in azimuth and elevation in monaural listeners. We hypothesize that better high frequency hearing will lead to better monaural spatial hearing abilities.

Design: Sound localization abilities in azimuth and elevation was studied in 20 adult single-sided deafness listeners. All subjects had normal hearing audiometric thresholds below 6,000 Hz. Stimuli consisted of 150 ms 20 - 20,000 Hz broadband noise bursts, high-pass noise bursts > 3 kHz, and low-pass noise bursts< 1.5 kHz, presented in random order from a 46-speaker array spanning +/- 90° azimuth and +/- 30° in elevation at 50, 60, and 70 dBA. Listeners were instructed to orient their head toward the perceived stimulus location as fast and as accurately as possible. Response accuracy was determined by head-orientation. Velocity of the head movement was also recorded to examine response variability and the promptness of the response. The difference between the onset of head movement and the onset of the target sound in milliseconds was taken and the average of the reciprocal of each participant's reaction time for each stimulus was computed. Linear regression was performed using the least-squared error criterion on the location points. The regression was performed on the target azimuth/elevation and the response azimuth/elevation angle. Analysis included response bias, gain, coefficient of determination (r2), and mean absolute error.

Results: Listeners demonstrated good localization in elevation and a response bias in azimuth for signals directed at the better hearing ear. There was a significant improvement in localization abilities for sounds presented to the better hearing ear compared to those presented to the deafened ear ($p< 0.001$). A significant decrease in localization performance occurs with increasing hearing loss in the extended

high frequency hearing range above 6,000 Hz of the good ear, evidenced by significant reductions in response gain and low coefficient of determination ($p < 0.001$, $r2 = .37$). Promptness of the response is significantly decreased in monaural listeners compared to normal hearers ($p < 0.05$), and promptness is observed to be decreased at the deafened side compared to the hearing side. Response variability was observed to significantly increase for signals presented to the impaired ear compared to signals presented to the better hearing ear ($p < 0.05$).

Conclusions: Improved localization abilities were positively associated with better extended high frequency hearing in monaural listeners, even in azimuth. Results suggest that access to extended high frequency monaural spectral cues gives rise to improved sound localization abilities in monaural listeners at the better hearing side and that some listeners can leverage these cues to improve monaural spatial hearing abilities. Localization behavior reflects significant increase in response variability and a decrease in promptness of the response that is associated with reduced localization performance.

PODIUM SESSION IV: AMPLIFICATION II – ACHIEVE

Design, Recruitment, and Baseline Characteristics of the ACHIEVE Study

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Objectives: Hearing loss is highly prevalent among older adults and independently associated with cognitive decline. The Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study is a multicenter randomized control trial (partially nested within the infrastructure of an observational cohort study, the Atherosclerosis Risk in Communities [ARIC] study) to determine the efficacy of best-practice hearing treatment to reduce cognitive decline over 3 years. The goal of this presentation is to describe the design, recruitment process, and baseline characteristics of the ACHIEVE study.

Design: The ACHIEVE study is a large multicenter randomized trial designed to determine efficacy of hearing treatment in reducing cognitive decline in older adults. Community-dwelling participants aged 70-84 years with adult-onset hearing loss who were free of substantial cognitive impairment were randomized 1:1 to a best practice hearing intervention or a successful aging health education control intervention. The primary outcome is change from baseline to the 3-year follow-up assessment in a global cognitive function factor score that is derived from a comprehensive cognitive test battery. Multiple strategies were used to recruit community-dwelling 70-84-year-old participants with adult-onset hearing loss who were free of substantial cognitive impairment from the parent ARIC study and de novo from the surrounding communities into the trial. Participants completed telephone screening, an in-person hearing, vision, and cognitive screening, and a comprehensive hearing assessment to determine eligibility.

Results: Over a 24-month period, 3004 telephone screenings resulted in 2344 in-person hearing, vision, and cognition screenings and 1294 comprehensive hearing screenings. Among 1102 eligible, 977 were randomized into the trial (median age = 76.4 years; 53.5% female; 87.8% White; 53.3% held a Bachelor's degree or higher). Participants recruited through the ARIC study were recruited much earlier and were less likely to report hearing loss interfered with their quality of life relative to participants recruited de novo from the community. Minor differences in baseline hearing or health characteristics were found by recruitment route (i.e., ARIC study or de novo) and by study site.

Conclusions: The ACHIEVE study successfully completed enrollment over 2 years that met originally projected rates of recruitment. Substantial operational and scientific efficiencies during study startup were achieved through embedding this trial within the infrastructure of a longstanding and well-established observational study. An important consideration in the interpretation of the ACHIEVE study findings will be differences between those recruited from a well-established epidemiologic trial and the de novo community participants who were generally healthier and more highly educated. The latter group may represent a healthy volunteer or worried well effect that is common in studies whereby many volunteers join because of means and concern for their health.

Design and Implementation of Patient-Centered Interventions for the ACHIEVE Study

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Objectives: We will describe the development and implementation of the evidence-based, person-centered interventions for use in the multi-site Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study [Clinicaltrials.gov NCT03243422; NIH funded R01AG055426]. The ACHIEVE study was the first large-scale randomized controlled trial to evaluate the effect of a best-practices hearing intervention versus a health education control on 3-year trajectory of cognitive decline in older adults with untreated hearing loss. We will also describe participants' baseline audiological characteristics and discuss the associations between select participant demographic and audiometric characteristics, speech-understanding in noise, and self-perceived hearing difficulties and how these factors influenced the design, implementation, and successful compliance of the hearing intervention.

Design: ACHIEVE participants were 977 community-dwelling adults aged 70-84 years with untreated hearing loss (better ear pure tone average [0.5-4 kHz] ≥30 and<70 dB HL) and without substantial cognitive impairment. Participants were recruited in 2018-2019 from four study sites in the U.S. (Jackson, MS, Forsyth County, NC, Minneapolis, MN, Washington County, MD). Participants were randomized to one of two patient-centered interventions. The successful aging education control intervention followed the protocol and materials developed for the 10 Keys to Healthy Aging (10Keys™), an evidence-based interactive health education program for older adults on topics relevant to chronic disease and disability prevention, previously implemented in other trials. The best-practices hearing intervention was developed from practice guidelines, expert consultation, and vetted through feasibility and pilot studies. Elements of the hearing intervention, which were provided in four sessions delivered over 8-12 weeks after the completion of a comprehensive audiometric evaluation, included: (a) Assessment and Goal Settings; (b) Technical Aspects of Treatment; (c) Orientation, Counseling and Self-

Management; and, (d) Outcomes Assessment. The audiologist-guided administration of the Client Oriented Scale of Improvement (COSI), used to elicit, prioritize, and categorize listening goals, served as the center of the intervention delivery.

Results: Median better ear pure tone average [0.5-4 kHz] was 38.8 dB HL; median poorer ear pure-tone average was 42.5 dB HL. Mean speech recognition in noise performance was 7.1 dB SNR Loss (SD= 5.2). Half (n=487, 50%) of participants had mild to moderate or worse hearing handicap (Hearing Handicap Inventory for the Elderly - Screening Version). The most frequent COSI listening goal categories were: conversation in noise (n= 413; 29%), conversations in quiet (n= 296; 21%), and TV/radio at normal volume (n= 280; 20%). We will discuss how participant characteristics informed the evidence-based, person-centered intervention protocols. Participants completed >90% of intervention sessions. Hearing intervention compliance was high based on data from datalogging and self-report.

Conclusions: Standardized yet personalized intervention protocols for older adults are critical for protocol compliance and intervention benefit. The rigorous design and implementation of the of the patient-centered interventions are critical for interpretation and contextualization of results from the ACHIEVE study.

Patient-Centered Selection of Hearing Technology and Related Outcomes from the ACHIEVE Study

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Objectives: To describe the hearing technology selection (based on speech in noise performance and individualized, prioritized listening and communication goals) for older adults randomized to a best-practice hearing intervention as part of the Aging and Cognitive Health Evaluation in Elders clinical trial (ACHIEVE Study). We also sought to determine if daily hours of hearing aid use and/or listening and communication goal achievement differed by technology level.

Design: The purpose of the ACHIEVE Study was to determine the effect of a best-practices hearing intervention vs. successful aging health education control on 3-year trajectory of cognitive decline in older adults with hearing loss. Participants were aged 70-84 years, had adult-onset hearing loss (better-ear 4-frequency (0.5-4kHz) pure-tone average [PTA] ≥30dBHL and<70dBHL), no current hearing aid use, and without substantial cognitive impairment at baseline. Participants were recruited from the Atherosclerosis in Communities (ARIC) study or de novo from surrounding communities at four sites: Washington County, MD, Forsyth County, NC, Jackson, MS, and Minneapolis, MN. Participants randomized to the hearing intervention were fit with basic, intermediate, or advanced hearing aid technology and offered at least 1 hearing assistive technology (HAT). Speech-in-noise ability was measured in soundfield in unaided and aided conditions using QuickSIN sentences. The Client-Oriented Scale of Improvement (COSI) was used to identify and prioritize patient-centered listening needs and to

assess attainment of hearing-related communication goals (self-reported degree of change; final hearing ability) following 8-12 weeks of hearing device use. We described participant characteristics, daily hours of hearing aid use, and COSI goal attainment by hearing aid technology level. We also estimated the association between hearing aid technology level, HATs provided, and changes in hearing-related communication using an ordered logistic model adjusting for PTA, unaided QuickSIN, age in years, sex, field site, education level, and study recruitment route (ARIC vs. de novo). Proportionality odds assumption was checked for all models.

Results: Hearing aid technology and HAT selection were based on unaided QuickSIN performance, COSI goals, and personal preference. A total of N=484 participants completed the hearing intervention. A total of 92 (19%) received basic, 278 (57.4%) intermediate, and 114 (23.6%) advanced hearing technology. Participants receiving basic technology had lower PTA (37.8 dB HL) when compared to intermediate (39.6 dB HL) and advanced (40.8 dB HL). Mean daily hours of use did not differ between technology levels (p=.41). Across all technology levels, participant COSI goals included conversation in noise and in quiet and attending church and/or meetings. Degree of change and final listening ability improved in the majority of participants regardless of technology. We found no statistically significant association between device type (hearing aid technology level, HATs) and change in COSI goals.

Conclusions: Our results are consistent with previous studies that demonstrated no associations between hearing aid technology level, hours of hearing aid use, and listening and communication outcomes. The patient-centered selection of hearing technology used in the ACHIEVE study resulted in COSI listening goal attainment for the majority of participants. Participants appreciated hearing-related benefit regardless of level of hearing aid technology or HAT.

Effect of Hearing Intervention on Cognitive Decline: The ACHIEVE Trial

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Objectives: Hearing loss in older adults is linked to faster rates of cognitive decline and risk of incident cognitive impairment in population-based observational studies. We tested whether hearing intervention could reduce cognitive decline in cognitively healthy older adults with hearing loss in a randomized controlled trial.

Design: The NIH-funded multicenter, parallel-group, unmasked ACHIEVE randomized controlled trial (ClinicalTrials.Gov: NCT03243422) tested the efficacy of a best-practices hearing intervention (audiological provision of hearing aids and related technologies, counselling, and education) versus a health education control intervention (individual sessions with a health educator covering topics relevant to chronic disease and disability prevention), on 3-year cognitive decline in 977 adults aged 70-84 years with untreated mild-to-moderate hearing loss. All participants were without substantial cognitive impairment at baseline. Participants were recruited from two study populations at each of 4 study sites in the U.S., including adults from a long-standing observational study of cardiovascular health (the Atherosclerosis Risk in Communities [ARIC] study), and healthy volunteers recruited de novo from the community. Each intervention consisted of 4 initial sessions, with semi-annual booster sessions for 3 years. Randomization was 1:1. The primary endpoint was 3-year change in a global cognition standardized factor score derived from a 10-test neurocognitive battery and summarized using latent variable methods. Secondary cognitive outcomes included domain-specific cognitive declines in memory, language and executive function and time until cognitive impairment, defined as a composite of adjudicated dementia or mild cognitive impairment diagnosis, a 3-point drop in the 30-item Mini-Mental State Exam (MMSE) administered in-person, or a 3-point drop in a factor score derived from the 10-item MMSE orientation subscale and 11-item Blessed scale administered over the phone and rescaled to be equivalent to the 30-item MMSE. Consistent with best practices for trials, primary analysis was by intention to treat, using adjusted linear mixed effects models.

Results: Overall, 54% of participants were female and 88% were self-reported White race. Mean age was 76.8±4.0 years. Compared to the de novo cohort, participants from ARIC were older, had more risk factors for cognitive decline (e.g., lower educational attainment, more likely to live alone, higher proportion with diabetes), and had lower cognitive scores at baseline. In the primary analysis, hearing intervention did not reduce 3-year cognitive decline (difference comparing hearing intervention to control: 0.002 standard deviation [SD] units [95% confidence interval (CI): -0.077 to 0.081]; p=0.96). In a prespecified sensitivity analysis, the hearing intervention reduced 3-year cognitive change in the ARIC cohort by 48% (difference comparing intervention to control: 0.191 SD [95% CI: 0.022 to 0.360]; p=0.027), but not in the de novo cohort (p-interaction=0.010). In the entire study population, the intervention did not reduce domain-specific cognitive decline or risk of cognitive impairment.

Conclusions: Hearing intervention did not reduce 3-year cognitive decline in the total cohort. In a prespecified analysis, the effect of the intervention differed by study population, suggesting that hearing intervention might reduce 3-year cognitive decline in older adults at increased risk for cognitive decline.

Effect of Hearing Intervention on Three-Year Change in Brain Morphology

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Objectives: Prior longitudinal studies among older adults have documented associations between hearing loss and changes in brain morphology. Whether interventions involving hearing aids could reduce decline in brain volume and cortical thickness is unknown. A substudy within the Aging and Cognitive Health Evaluation in Elders (ACHIEVE, Clinicaltrials.gov Identifier: NCT03243422) randomized controlled trial tested the effect of a best-practices hearing intervention versus health education control on three-year change in brain volume and cortical thickness among older adults with hearing loss.

Design: The ACHIEVE study enrolled 977 community-dwelling adults aged 70-84 years at baseline (2018-2019) with untreated hearing loss (better ear pure tone average [0.5-4 kHz] ≥30 and<70 dB HL) and without substantial cognitive impairment from four sites across the U.S. (Jackson, MS, Forsyth County, NC, Minneapolis, MN, Washington County, MD). Participants were randomized to a hearing intervention (provision of hearing aids and related technologies, counseling, and education) or a health education control (individual sessions with a health educator covering topics relevant to chronic disease and disability prevention). Three-dimensional magnetic resonance imaging was performed on 3 Tesla Siemens scanners in a subsample of 445 participants at the ACHIEVE baseline and a three-year follow-up. Intention-to-treat analyses involving linear mixed effects models examined three-year change in brain volume and cortical thickness. All models adjusted for baseline measures of hearing loss, recruitment source, study site, age, sex, and education. Models examining brain volume additionally adjusted for total intracranial volume. Missing outcome and covariate data was imputed to mitigate bias caused by informative attrition.

Results: At baseline, 224 participants were women (50.3%), 52 participants were Black (11.7%), and the mean (SD) age was 76.4 (4.0) years old. The mean pure tone average was 39.3 (7.0) dB HL, and the average score on the Mini-Mental State Exam was 28.2 (1.7). Compared to the health education control, the hearing intervention exhibited a nominally protective effect on three-year change in average cortical thickness (0.012 mm, 95% CI: 0.000, 0.024, p: 0.057, Cohen's D: 0.105) and total brain volume (795 mm3, 95% CI: -3366, 4956, p: 0.71, Cohen's D: 0.023), although neither effect was statistically significant. The greatest effect size for cortical thickness was observed in the occipital lobe (0.011 mm, 95% CI: 0.000,

0.023, p: 0.051, Cohen's D: 0.113), while the smallest effect size was detected in the temporal lobe (0.006 mm, 95% CI: -0.009, 0.022, p: 0.44, Cohen's D: 0.047).

Conclusions: Hearing aid use may reduce decline in cortical thickness among older adults. The effects of hearing aids may be greatest in regions other than those associated with the auditory cortex.

Utilization of Audiological Services During the ACHIEVE Hearing Intervention

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Objectives: To describe the utilization use of audiological services during the provision of a best-practices hearing intervention over a 3-year period in the Aging and Cognitive Health Evaluation in Elders (ACHIEVE, Clinicaltrials.gov Identifier: NCT03243422) hearing intervention. The ACHIEVE randomized controlled trial tests the effect of a hearing intervention vs. a successful aging health education control group on cognitive decline among older adults with hearing loss. As participants assigned to the HI intervention were provided with hearing aids and additional hearing technologies, in additional of being able to contact their audiologist whenever needed, at no charge, the ACHIEVE trial provides a unique opportunity to assess utilization of audiological services from a best-practices perspective.

Design: A total of 977 older (70-84 years) community-dwelling adults with mild to moderate untreated hearing loss (four-frequency [0.5/1/2/4 kHz] better ear pure tone average (PTA) ≥ 30 and<70 dB HL) and without substantial cognitive impairment were included. Participants were recruited from four U.S. sites (Jackson, MS, Forsyth, NC, Minneapolis, MN, Washington County, MD). As part of the hearing intervention, participants were provided with hearing aids (HA), hearing assistive technologies (HAT's, e.g. remote microphone), counseling, and education. Hearing aids were delivered during four initial sessions and then participants were seen every 6 months for 3 years. Participants were able to contact the study audiologist between visits if additional support was needed for the adjustments and repair or hearing aids and HAT's. We identified and classified all interactions with the study audiologists during

the initial phase of the hearing intervention, and then by one and three years after enrollment. Interactions were classified by type (telephone, email, or in-person), and reason for the interaction: hearing aid (not functioning, volume problems, fitting, noise/feedback, cleaning, or loss of device), or HAT related (not functioning or loss).

Results: A total of 486 participants received the hearing intervention. During the initial delivery of the hearing intervention, 342 (70.7%) participants were seen during the four scheduled visits only, 88 (18.2%) required an additional encounter with the audiologist, and 54 (11.1%) required two or more additional encounters. On average, in addition to the planned scheduled visits (6 by Year 1 and 10 by Year 3), participants were seen and additional 1.2 (standard deviation (SD)=1.72) times, and 3.6 (SD=1.72) times during the first year of the intervention and by Year 3 respectively. During the entire study period, most of the unscheduled visits were in-person (65.2%), followed by telephone (32.1%) and email (2.7%). Among visits, 30.2% were related to the hearing aid not functioning, 8.3% to volume and noise, 4.7% to fitting, and 4.5% were related to HATs. 12.1% of these additional visits required a replacement of the hearing aid, while 25.7% required an in-office repair.

Conclusions: The ACHIEVE trial provides a unique opportunity to assess utilization of audiological services during provision of a best-practices hearing intervention. Our estimates demonstrate that about 30% of study participants required additional visits during the initial hearing intervention delivery process and that on average, and additional encounter was needed for maintenance of the hearing intervention during a 3-year period. These estimates provide a benchmark for clinicians, policy makers, and other stakeholders of the audiological services needed during the delivery and maintenance of a best-practices hearing intervention.

Addressing Technological Barriers to Hearing Care: HEARS RCT

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Objectives: The digital divide in the United States persists among low-income older adults, where less than one-third of low-income older adults own a smartphone and more than half have never used the internet. With the advent of over-the-counter (OTC) hearing aids that often rely on technologies such as smartphones, disparities in hearing care have the potential to worsen among older adults. Currently, only 15% of low-income older Americans with hearing loss use hearing aids as compared to 36% of older Americans with higher incomes. Strategies are needed to connect older adults with hearing loss to new technologies. Task sharing, specifically partnering with community health workers, may be one strategy to minimize the effects of differential technology usage and access for hearing care use among older adults with hearing loss. We investigated whether prior technology use modified the effect of a hearing intervention delivered by community health workers that leverages OTC hearing technology.

Design: Baltimore HEARS was a randomized controlled trial where adults 60+ years old with untreated mild to moderate hearing loss and functional communication impairment (HHIE-S ≥ 8) were assigned to a wait list control group or received a community health worker-delivered hearing intervention and low-cost OTC device. The primary outcome was the change from baseline in HHIE-S score at 3-months post-randomization. Participants were recruited from affordable, independent housing complexes for older adults and senior centers across Baltimore, MD. For this secondary analysis, participants were categorized according to their use of technology, with participants who either owned a smartphone or used the internet, emailed, or texted in the past month categorized as 'tech connected' with other participants categorized as 'not tech connected.' The average treatment effect of the intervention was computed using doubly robust weighted least squares.

Results: Of the 151 randomized participants, 28.4% were not tech connected. 50.3% did not have or use a computer in the last month, 39.1% did not send text or email messages in the last month, and 66.2% did not use or have a tablet. 51.7% had mild hearing loss and 48.3% had moderate or greater hearing loss. 63.6% of participants identified as low-income with<$25,000 in annual household income. Among tech connected individuals, treated individuals demonstrated a decrease in communication impairment of -14.1 (95% CI: -17.6, -9.9) points on the HHIE-S as compared to the controls. Similarly, treated individuals who were not tech connected had a decrease in communication impairment of -12.5 (95% CI: -16.2, -5.2) points on the HHIE-S as compared to controls. The difference in treatment effect between these groups was -1.55 (95% CI: -7.8, 4.1) points on the HHIE-S.

Conclusions: Technology use did not modify the effect of the HEARS intervention. Hearing care interventions that incorporate OTC hearing technology along with support by community health workers, may be a promising approach in overcoming potential barriers to hearing care among older adults, including barriers related to technology use and access.

Medicare Annual Wellness Visit: Opportunity for Systematic Support for Hearing

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Objectives: Few studies have characterized the path towards hearing care for older adults starting from primary care- from initial indication of hearing concern through hearing evaluation to management. The electronic medical record (EMR) includes diagnosis of health conditions, but also rich contextual information of patient collected information of health concerns and provider visit discussion notes. The Medicare Annual Wellness Visit (AWV) presents a platform to systematically identify patient-reported hearing concerns and evaluate actions towards hearing care. Using the AWV and EMR data from a large academic health system, we explore how providers approach and discuss hearing concerns or care during visit interactions and how this is reflected in EMR. We hypothesize hearing loss or care is included in provider notes at a higher frequency than as documented in EMR.

Design: Using EMR data from 5-years (2017-2022) of observation, we identify the index indication of hearing concerns for AWV recipients during the study period. We first quantify the frequency of associated hearing loss diagnosis (via ICD/CPT codes or EMR problem list) and referral for hearing care following the primary care visit with initial indication of hearing concern. We then document indication of hearing loss or hearing aids and referrals discussion in providers notes on a 15% random sample of participants (n=363).

Results: Among 2,593 older adults (mean age 78.8 years, 56% female, 96% white, 21% prior hearing diagnosis in EMR) only 5.4% received an audiology referral within 3 months of AWV with index hearing concerns. Differences were observed in how or if hearing was recorded- only 11.5% included hearing loss on problem list and 37% included via encounter diagnosis only ($p=0.004$). Among the random sample with provider notes reviewed, 2 in 3 did not have hearing commented on in the note and only 10% had referral need noted by providers. Providers commonly noted known hearing loss or hearing aid use without having indication flagged in EMR ($p<0.001$; 31% no diagnosis, 46% encounter only). Providers were more likely to incorporate hearing concerns in notes for patients with less chronic conditions or cognitive concerns ($p<0.001$) regardless of previously identified hearing status.

Conclusions: Discussion of hearing concerns or provider documentation/action for hearing care is limited during Annual Wellness Visits within this large academic health system. Exploring innovative ways to embed and implement systematic support for providers hearing health education or resources in EMR and or to facilitate indication of hearing loss in the patient chart for all health team members to note may improve patient-provider communication, information exchange, and high-quality care.

PODIUM SESSION V: OTOTOXICITY & TINNITUS

A Multinational Delphi Consensus on Program Objectives for Ototoxicity Management

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Objectives: The International Ototoxicity Management Group (IOMG) is an interdisciplinary effort to address ototoxicity from medical, occupational and environmental exposures worldwide. This project sought to establish consensus among IOMG members on 1) program objectives for high-quality ototoxicity management (OtoM), 2) protocols for ototoxicity symptom surveillance, and 3) implementation strategies in diverse contexts, such as, across global regions, healthcare structures, exposure settings, and patient populations. This presentation describes the initial part of the project, which involved development of unified OtoM program objectives.

Design: We used a two-round, modified electronic Dephi method to achieve consensus. The mixed methods survey was developed through input from past IOMG efforts addressing the three objectives above. Survey design included breakout room activities, and an international predevelopment panel, mapped to domains of the Consolidated Framework for Implementation Research and administered using Qualtrics. The survey was sent to approximately 130 researchers, clinicians and patients affiliated with IOMG, with instructions to participate if they were familiar with OtoM provision. Survey questions used various types of response scales. Additional questions captured information on the specific OtoM context, and current levels of implementation of the proposed objectives.

Results: Forty-four individuals completed the survey with 61% (n=27) indicating they are familiar with OtoM service provision in the region of the Americas, 15% (n=7) in Europe, 9% (n=4) in Africa, 9% (n=4) in the Western Pacific, and 5% (n=2) from Southeast Asia. An overwhelming majority endorsed the following proposed OtoM program objectives: (1) Using a proactive, health surveillance approach to identify at-risk patients (97%, n=43); (2) Providing education/counseling, enabling patients to discuss risk and rehabilitation options (100%, n=44); (3A) Co-developing OtoM plans with patients from a standardized menu of options (89%, n=39); (3B) Providing active structured hearing-health surveillance with a baseline as the default option (97%, n=43); (3C) Providing a secondary screening option (93%, n=41); (3D) Providing self-directed educational materials to adults who opt-out of other OtoM options (89%, n=39); (4) Establishing interdisciplinary practice plans with institutional partners (97%, n=43); and (5) Developing OtoM program evaluation with standardized outcomes (91%, n=40). Although

respondents collectively endorse these objectives for high-quality OtoM, responses were more nuanced on whether proposed objectives were implemented. The most widely implemented objectives related to proactively identifying at-risk patients: (objective 1, 62%, n=26), providing them education/counseling (objective 2, 61%, n=25), and providing active hearing-health surveillance with a baseline (objective 3B, 61%, n=25). Conversely, respondents reported that providing an education only option (objective 3D, 15%, n=6), providing a screening option (objective 3C, 23%, n=9), and program evaluation (objective 5, 28%, n=11) had not been widely implemented.

Conclusions: The result of this project is a multinational consensus that high-quality OtoM programs are those that proactively engage at-risk patients, codify interdisciplinary/institutional collaborations, and employ standardized evaluation processes. While there is widespread agreement on objectives, variations in implementation across global regions indicate the need for tailored strategies. The nuanced responses underscore the complexity of integrating these objectives into diverse contexts, highlight the need for further collaborative efforts to bridge the gap between consensus and practical application of OtoM worldwide.

Ototoxicity Profiles of Patients Receiving Alternate Cisplatin Administration Schedules

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Objectives: Both the American Speech-Language-Hearing Association (ASHA) and the American Academy of Audiology (AAA), endorse routine ototoxicity management, including baseline auditory assessment and regular monitoring visits during and after cisplatin-based chemotherapy. Yet there currently is no widespread adoption of ototoxicity management protocols clinically. Perceived barriers to "real world" implementation include logistics relating to accessing and testing patients, limitations in personnel and institutional resources, but also the lack of public knowledge about the risk of cisplatin-induced hearing loss as it varies across different cancer types and treatment approaches. This study was designed to characterize the onset, incidence, and severity of hearing loss as influenced by different cisplatin treatment schedules, specifically, individual cisplatin dose, in adults treated with cisplatin-based chemotherapy. We hypothesized that individuals with reduced individual cisplatin doses would show later onset and reduced severity of hearing loss following their cancer therapy.

Design: We conducted a large-scale, multi-site retrospective study to examine hearing thresholds from 739 adult cancer patients (587 (79.4%) male, 152 (20.6%) female) treated with cisplatin. Threshold shifts were calculated as the difference in behavioral thresholds obtained at baseline (pre-cisplatin therapy) and follow-up (during and 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 onset, incidence and severity of cisplatin-induced hearing loss between patients receiving different cisplatin treatment schedules (high/bolus doses once every three weeks (≥75 mg/m2) versus low weekly doses(<70 mg/m2).

Results: Overall, a CTCAE grade ≥1 hearing loss was detected in 60.9% of patients treated with cisplatin. However, the incidence of hearing loss varied significantly according to cisplatin schedule with hearing loss observed in 70.7% of patients receiving a high dose schedule of cisplatin treatment (average cumulative dose 248.9 mg/m2 +/- 107.2) compared to 43.8% of patients receiving a low dose schedule of cisplatin treatment (average cumulative dose 207.2 mg/m2 +/- 90.4). Moreover, the individual dose schedule significantly impacted the onset of hearing loss, with only 22.1% presenting with hearing loss after 100-200 mg/m2 cisplatin and 31.0% after 200-300 mg/m2 low-dose schedule of cisplatin treatment versus 37.9% and 47.7%, respectively. For the 28.1% of patients enrolled in an ototoxicity monitoring program, on average, 3.3 audiograms were obtained per patient (range 2-10) spanning the timeframe between baseline and cessation of cisplatin treatment. 65.6% patients were started on a high dose (≥75 mg/m2, once weekly) schedule of cisplatin administration. Upon early detection of hearing loss, 11.9% were switched to a lower dose of cisplatin for subsequent infusions or changed to carboplatin.

Conclusions: Recommendations to and compliance with recommended ototoxicity monitoring may be enhanced with better understanding of the timing and severity of ototoxicity symptoms. Those requiring higher individual dose schedules of cisplatin administration are at greater risk for hearing loss and should therefore be monitored more closely to provide opportunities for either adjustments in treatment or audiology consultation.

Rise of the Machines: Modeling to Predict and Prevent Ototoxicity

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Objectives: Current methods to detect and predict ototoxic hearing loss stemming from cancer treatments often rely on subjective grading scales, hindering effective communication and accurate interpretation for diverse stakeholders. These limitations in existing approaches have propelled the development of an innovative Bayesian statistical model of hearing by our group. This tool, based on flexible algorithms, aims to advance auditory monitoring by generating patient-specific acceptable ranges of hearing variation, allowing for straightforward interpretation across various settings and accelerating the identification of potential hearing damage.Traditional grading scales used in hearing science often pose challenges in interpretation, especially for individuals outside the field. Our algorithmic tool

overcomes these hurdles by providing simplified, patient-specific metrics, enabling swift and comprehensible assessments regardless of the user's expertise. Furthermore, this tool's adaptability allows for forecasting potential hearing loss, augmenting its utility in mitigating ototoxic hearing losses.

Design: The study involved 85 Veterans from the VA Portland Health Care System. Auditory measures included conventional and high-frequency audiometry, distortion product otoacoustic emissions, and wideband middle ear muscle reflexes. Genetic information was obtained through a single blood sample. Additionally, patient-specific data related to cancer diagnosis and treatment were extracted from medical records. Data was collected at three time points: a pre-treatment baseline and follow-up visits at 30 and 365 days post-baseline.Additional information was drawn from several large national databases of control subjects to generate frequency-specific ranges of test-retest variability over time.

Results: Using the above test measures, two different tools were developed. The first uses patient demographic data combined with auditory and genetic information to generate frequency-specific acceptable ranges of variation for hearing in the absence of auditory damage. This allows audiologists and other stakeholders to easily identify changes to auditory function outside of expected ranges without the use of complex, context-specific grading scales. This creates a hearing loss detection tool that is sensitive in a variety of settings, including ototoxicity monitoring.The second tool pairs these patient-specific factors with planned cancer treatments to predict hearing loss from platin-based chemotherapies. This can be used as a patient counseling or treatment planning tool to generate expected ranges of hearing following administration of chemotherapy. This can better inform providers on how specific chemotherapy doses may interact with patient-specific risk factors and help to estimate the impact of these therapies on post-treatment quality of life.

Conclusions: By leveraging statistical learning, this study aimed to create practical tools for rapid and precise detection and prediction of hearing loss. The utilization of patient-specific ranges for acceptable hearing variations and the predictive modeling of potential hearing loss continue previous breakthroughs in auditory monitoring and prediction, offering widespread benefits in clinical and occupational contexts.This novel approach holds promise in facilitating timely identification of hearing changes, a major factor in mitigating the risk of future hearing impairments caused by cancer treatments. The integration of patient-specific statistical learning tools in auditory monitoring can empower healthcare providers, employers, physicians, employees, and patients alike, advancing toward an era of proactive and personalized hearing healthcare across diverse sectors.

Randomized, Placebo-Controlled Interventional Study of Atorvastatin to Prevent Cisplatin-Induced Ototoxicity

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Objectives: Cisplatin is a widely-used and effective anti-cancer drug used to treat a variety of solid tumors. It is also the most ototoxic drug in clinical use causing significant, irreversible hearing loss in over 50% of treated patients. There is a major need for therapies that reduce cisplatin-induced hearing loss. In pediatric patients with non-metastatic solid tumors, Pedmark, a formulation of sodium thiosulfate (STS), is now FDA-approved to mitigate the risk of hearing loss. However, there remains a critical need for therapies to protect the hearing of patients scheduled to receive cisplatin who are not candidates for Pedmark. We have previously examined, in mice and in humans, the potential for concomitant use of statins during cisplatin-based chemotherapy to reduce or prevent hearing loss. Statins are FDA-approved drugs with good safety profiles in humans, and they do not reduce the therapeutic efficacy of cisplatin. Here we present a planned interventional clinical trial to definitively determine the extent to which atorvastatin reduces the incidence and severity of cisplatin-induced hearing loss in adults treated with cisplatin for head and neck cancer.

Design: Up to 214 adult male and female patients newly-diagnosed with head and neck cancer scheduled to undergo cisplatin-based chemoradiation therapy will be enrolled in this multi-site, Phase II randomized, placebo-controlled interventional trial. Participants will be randomized to receive either once daily atorvastatin (40 mg, PO) or placebo beginning 1-week prior to start of cisplatin treatment, throughout the duration of standard of care cancer treatment, and through to their 3-month follow up (post-treatment) appointment. Survivorship data will be collected at the 2-year follow up study visit. Hearing tests, including air conduction behavioral audiometry and tympanometry, and self-reported questionnaires designed to assess tinnitus, hearing, balance and quality of life will be administered during baseline (pre-cisplatin treatment), 3-month and 2-year post-cisplatin study visits.

Results: This study has received NIH U01 Research Project-Cooperative Agreement funding and IRB approval. Enrollment at four participating sites is planned for Spring 2024.

Conclusions: Our preclinical and clinical studies suggest that statin use is associated with significantly reduced incidence and severity of hearing loss. If the results of this trial confirm that atorvastatin, an inexpensive drug with a good safety profile, reduces cisplatin-induced hearing loss, this intervention can be rapidly translated to patients.

Detection and Diagnosis of Ototoxicity from Occupational Exposures: A Review

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Objectives: Across countries, no standard methods exist for the auditory surveillance of individuals exposed to hazardous chemicals at work. Members of the Environmental & Occupational Focus Area of International Ototoxicity Management Group (IOMG, https://www.ncrar.research.va.gov/ClinicianResources/IOMG.asp) came together to contribute to the

development of programs to identify and provide care to exposed populations. A mixed methods review was conducted to scope the literature, identify knowledge gaps, appraise results, and synthesize the evidence on the audiological evaluation of workers exposed to solvents.

Design: We searched Medline; PubMed; Embase; CINAHL; NIOSHTIC-2. Using Covidence, 2 authors independently assessed study eligibility, risk of bias, and extracted data. We used the National Institute of Health Quality Assessment Tools in the quality evaluation of included studies and the Downs and Black checklist to assess the risk of bias.

Results: Of 454 identified references, 37 studies were included for analysis. Twenty-five different tests were used in the various studies. Given the differences in methodology, substances investigated and designs, it was unfeasible to conduct a full systematic review and meta-analysis at this point in time. However, we were able to apply many key methods of a systematic review, in particular the quality assessment of the included studies and the risk of bias. A variety of tests have been used to evaluate many aspects of auditory function in workers exposed to solvents. Specifically, twenty-five different tests were used in the various studies: two behavioral tests to measure hearing thresholds (conventional and extended-high frequency pure-tone audiometry), one behavioral test of word recognition in quiet, six different electroacoustic procedures (Acoustic reflex thresholds; Acoustic reflex decay; Spontaneous otoacoustic emissions; Transient evoked otoacoustic emissions (TEOAEs); Contralateral suppression of TEOAEs; Distortion product otoacoustic emissions), four different types of electrophysiological tests (Auditory Brainstem Response; Cortical Response Audiometry; Late Auditory Evoked Potentials; P300), twelve behavioral tests to assess auditory processing skills and one self-report questionnaire on listening difficulties (Amsterdam Inventory for Auditory Disability and Handicap).

Conclusions: The quality of individual studies was mostly considered moderate, but the overall quality of evidence was considered low. While discrepancies between studies and differences in the methodologies /outcomes prevent us from recommending a specific test battery to assess the auditory effects of ototoxic chemicals it allows us to identify the type of auditory dysfunctions to be expected and characteristics that an audiological test battery should have. This study is facilitating the development of consensus statements in ototoxicity management in the workplace. The IOMG has expanded stakeholder engagement. Its multicultural and interdisciplinary approach is needed to support application of ototoxicity management in specific medical, environmental and occupational contexts worldwide.Disclaimer: The findings and conclusions in this presentation are those of the presenter and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Mention of any company or product does not constitute endorsement by NIOSH or the CDC. This work is intended to align with the IOMG mission and its views for effective ototoxicity management.

Acceptability and Effectiveness of Remote Counseling for Tinnitus

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Objectives: Tinnitus Activities Treatment (TAT) is well established program to help patients with bothersome tinnitus. TAT provides counseling on tinnitus and related problems like depression + anxiety, concentration, hearing, and insomnia; suggests coping strategies for tinnitus; and recommends

sound therapy via partial masking for tinnitus relief. TAT uses a collaborative approach to set patient-specific goals for therapy and incorporates picture-based counseling in management of tinnitus. In 2020, after updating TAT materials, we realized the potential in providing tinnitus management therapy to patients beyond those in our clinics, especially given the rise in cost of healthcare and anticipated expansion of audiological services to the general public via over-the-counter hearing aids. We developed a remote counseling program, TAT-Online, based on our experience with in-person therapy. To investigate the feasibility of TAT-Online, we conducted a pilot study with 26 adults with tinnitus in 2022. We have now enrolled 193 adults with tinnitus that provides a reasonable sample size to test the acceptability and effectiveness of our remote counseling program for tinnitus.

Design: Participants completed weekly modules that included 2-3 recorded videos, homework to practice strategies, and quizzes to assess learning. Participants completed the sessions in a self-paced manner according to following 6-week schedule: Week 1 - Questionnaires and Introduction; Week 2: Thoughts and Emotions; Week 3: Sleep; Week 4: Hearing; Week 5: Concentration; and Week 6: Relaxation Techniques and Sound Therapy. We included adults with chronic tinnitus who had access to a smartphone, tablet or computer. We recruited a large sample of 272 adults with chronic tinnitus via radio and newspaper advertising in our local community as well as nationally from the American Tinnitus Association. Of these 272, 193 participants were enrolled and 131 participants completed the program to date. A single subject design was used in this study with four outcome measures that included two questionnaires on tinnitus severity, tinnitus magnitude estimations, and a questionnaire on quality of life. The outcome measures to assess effectiveness were obtained before and after participation in the counseling program, and acceptability was determined based on an exit survey.

Results: The participants reported that the self-paced format of TAT-Online was acceptable and easy to follow, and effective for learning strategies for coping with their tinnitus. Mean ratings of effectiveness for the various TAT-Online activities were as follows: 9.2/10 for the videos, 7.1/10 for the homework, and 7.5/10 for the quizzes. Participants rated the effectiveness of TAT-Online for relieving their tinnitus at 62/100 (range: 10-100). Tinnitus severity was reduced in 60% and tinnitus annoyance was reduced in over 50% of the participants. We did not observe a worsening in their tinnitus severity with use of TAT-Online.

Conclusions: Remote counseling for tinnitus that includes asynchronous educational videos, reflection exercises and sound therapy recommendations is acceptable and effective in reducing tinnitus symptoms for many people with tinnitus. Our plans are to make TAT-Online available to audiologists for use with their tinnitus patients, as well as for the general public.

An Equal-Loudness Compensation Algorithm of Sound Therapy for Tinnitus with Hearing Loss

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Objectives: Sound therapy is a primary clinical intervention for tinnitus that seeks to alleviate its severity and negative impacts by modifying auditory perceptions. However, current methods of generating or modifying therapeutic sounds for tinnitus often face challenges in balancing effectiveness and comfort, particularly in instances of concurrent hearing loss and tinnitus.This study focuses on designing precise therapeutic sounds for individuals with tinnitus and hearing loss. Tailored to the unique characteristics

of patients experiencing both conditions, the research ensures accurate calibration. This calibration aims to guarantee effective perception, treatment outcomes, and comfort for individuals with coexisting tinnitus and hearing loss. The study emphasizes optimizing treatment for those with both conditions, addressing a critical gap in current therapeutic approaches.

Design: Addressing the combined scenario of tinnitus and hearing loss, this study introduces an energy compensation algorithm grounded in the principles of equal loudness contours. Leveraging parameters such as tinnitus frequency, tinnitus sound pressure level, tinnitus hearing threshold, and tinnitus equal loudness contours for patients with tinnitus and hearing loss, the algorithm meticulously calculates the compensatory sound pressure differences (D_f) required for equal loudness adjustment in each frequency band. This calculation is conducted with reference to the hearing thresholds and equal loudness contours of individuals with normal hearing.In practical use, the algorithmically determined sound pressure level differences (D_f) can be selectively applied in the frequency domain to modulate therapeutic sounds for tinnitus. Subsequent to this frequency domain modulation, precise equal loudness compensation for therapeutic sounds is achieved through time-frequency domain transformations, ensuring an accurate representation of the compensated sounds.

Results: This study conducted equal loudness processing experiments on 10 natural soundtracks. Simultaneously, factors such as the relative position of tinnitus frequency to the frequency range of hearing loss and the corresponding degree of loss equilibrium were considered. These factors led to the categorization of the coexistence of tinnitus and hearing loss into two paradigmatic classes: "Tinnitus accompanied by globally balanced hearing loss across all frequency bands" and "Tinnitus with uneven degrees of hearing loss across all bands." For the latter class, two sub-cases were defined based on the difference in the severity of hearing loss between the tinnitus frequency and other frequencies, namely, "Tinnitus with more severe low-frequency hearing loss" and "Tinnitus with more severe high-frequency hearing loss." There was a significant improvement in the correlation coefficient between the spectral characteristics before and after equal loudness compensation (rising from -0.183 before compensation to 0.679 after compensation). Significantly, based on paired-sample t-tests, there were notable differences in the correlation coefficients before and after processing for each coupling paradigm ($P = 0.001$). These findings underscore the consistent equal loudness perception of the customized therapeutic sounds across diverse hearing impairment scenarios.

Conclusions: This study presents an equal loudness compensation algorithm, founded on the principles of equal loudness contours, and specifically designed for patients with hearing loss. It ensures not only consistent perception of therapeutic sounds with those with normal hearing but also considers the comfort and effectiveness of sound therapy in cases of coexisting tinnitus and hearing loss.

Emotion Classification Performance Affected by Moderate to Severe Hearing Loss

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Objectives: The question addressed by this research was focussed on how the classification of vocally expressed emotion can be degraded for hearing-impaired (HI) listeners who use hearing aids, in comparison to normal-hearing (NH) listeners. The question asked was whether effects of moderate to severe hearing loss on sensitivity to vocally-expressed emotion could be assessed via a 6-Alternative

Forced Choice (6AFC) Emotion Classification Task. An attempt was made to control for the confounding effect of talker gender, which could have operated as follows: If vocal expressions of only one talker were heard, then a higher mean pitch of an utterance might have cued anger and amusement, while a lower mean pitch might have cued sadness and relief.

Design: Emotion classification performance of 32 normal hearing (NH) and 30 hearing impaired (HI) listeners was test under quiet conditions. To avoid response biases based upon the gender of the talker producing the target utterances, a male and female version of each of 20 vocal expressions of emotion were manipulated via analysis/synthesis via LPC (Linear Predictive Coding) to produce 20 new utterances heard as if produced by talkers of the opposite gender. Thus, 20 pairs of utterances with matched prosodic pitch contours and modulation spectral features could be presented with varying talker gender. To be clear, the female-talker versions were given higher mean fundamental frequency and were spectrally modified to exhibit formant variation characteristic of a shorter vocal-tract length. Data analysis also was completed to test the experimental hypotheses that were posed relating to the prediction of emotional classification performance using conventional prosodic features (using additional acoustic variables such as those based upon modulation spectral features).

Results: Classification Sensitivity was measured via d' score on 6-Alternative Forced Choice (6AFC) task that provided a sensitive test of emotion classification abilities. The classification performance of 32 normal hearing (NH) and 30 hearing impaired (HI) listeners in quiet conditions: $t (df = 60) = 5.86$ ($p < .01$). Furthermore, the differences in classification performance between groups could be predicted by the listeners' average hearing level across two low frequencies (250 & 500 Hz). A second predictor that accounted for a substantial amount of the variance in classification performance was the self-rated difficulty that listeners had understanding vocal expressions of emotion (revealed by their responses on the EMO-CHeQ questionnaire).

Conclusions: Classification sensitivity that was measured via d' score on 6-Alternative Forced Choice (6AFC) task provided a sensitive test of the effects of hearing loss on emotion classification abilities. The results demonstrated the effectiveness of counterbalancing talker gender for the classification task, which avoided the influence of this possible confound.

PODIUM SESSION VI: HEARING MEASURES & ELECTROPHYSIOLOGY

Rapid Clicks for Comprehensive Auditory Peripheral Health Estimation

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Objectives: Congenital hearing loss is detected through universal newborn hearing screening (UNHS) programs. Although this is a successful program overall, a few problems persist. (1) UNHS programs largely only exist in developed nations as it is costly, and (2) even in successful UNHS programs the cause

for failing the test cannot be deduced, leading to slower triage. We have developed a click-evoked otoacoustic emissions (OAEs) and auditory brainstem reflexes-based screening tool that has the potential to outperform the current standard of care (e.g., auditory brainstem response) as it is cheaper, less invasive, and more informative. Our goal in this study is to (1) acquire proof-of-concept data to determine whether our test can identify the three most common types of hearing deficits in children, i.e., conductive, cochlear, and neural, and (2) expedite the test, i.e., reduce test time from 8 mins to less than 2 mins, using rapid presentation of clicks and deconvolving overlapping responses using a multi-response deconvolution approach.

Design: Two groups of participants - children (5-17 years) and normal-hearing adults (18-30 years) - are being tested in the study to address our two goals. Data collection is ongoing in the children group with a prospective recruitment of 60 participants with 15 each representing conductive, cochlear, and neural deficits with normal hearing children as controls expected. Twenty-five adults have completed the study. For both groups, we parametrically varied click level (70, 80, 90 dB ppSPL) and rate (64, 128, 204, 256 Hz) to identify an optimal rate-level combination that provided the best estimate of the OAEs and the brainstem reflexes. Due to time restrictions, only a subset of the level and rate were included in the children group. Accurate estimation of the brainstem reflexes relies on estimating the change in OAEs over a 1s period.

Results: Results from adult participants show that it is feasible to obtain OAEs at rates up to 256 clicks/sec and levels up to 90 dB ppSPL using deconvolution. A linear mixed-effects model revealed significant main effects and interaction of level and rate: OAEs increasing with level and decreasing with rate. Importantly, deconvolved OAEs presented residual noise derived from an inefficient characterization of the large-magnitude stimulus (~50 dB larger than the OAE). Consequently, the brainstem reflex could only be observed at the group level, as individual effects were contaminated by residual noise.

Conclusions: Our results provide the first successful application of multi-response deconvolution in the estimation of OAEs and brainstem reflexes at high rates and levels. With further refinement of the deconvolution algorithm, we expect to be able to estimate brainstem reflexes at the individual level. Combining data from adults and children, we will present proof-of-concept data for a click-based peripheral screening test capable of detecting different hearing deficits rapidly.

Cochlear Tuning Estimates Following Resolved Otitis Media in Children

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Objectives: Otitis media (OM) is the second most common illness in children that visit the doctor's office. Several studies in human and animal models suggest that conductive hearing loss due to OM is associated with poorer signal detection in noise even after the OM resolves. In humans, hearing-in-noise deficits associated with resolved OM are often attributed to upstream deficits in central auditory processes; in contrast, it is assumed that peripheral frequency tuning remains intact. Sharp frequency tuning is a critical component of speech recognition in both quiet and competing background noise. However, recent studies in animal models have shown that round window transmission of OM-generated bacterial endotoxins to the cochlea may result in subclinical cochlear damage. Thus, it is possible that cochlear tuning may be affected by OM and that cochlear tuning deficits could contribute to increased

vulnerability to noise masking in children with resolved otitis media. The goal of the present study was to test the hypothesis that cochlear tuning may be poorer in children with resolved OM, and that these deficits could contribute to reduced perceptual masking in children with resolved OM.

Design: Cochlear tuning estimates (QERB) from 1000 to 4000 Hz at half-octave bins were obtained from stimulus frequency otoacoustic emission (SFOAE) delays measured using a 40 dB probe. Speech-in-noise recognition was measured using the Hearing-in-Noise Test for children (HINT-C). Typically developing children (5 to 13 years of age) participated in this study. Following a case-control design, participants were categorized into children with a medical history of OM (n = 76) and age-matched controls without medical history of OM (n = 99). All children had clinically normal audiograms (hearing thresholds< 25 dB HL from 250 to 8000 Hz) and normal tympanograms at the time of testing. Wideband absorbance was also measured. Analysis of covariance with the group as a fixed factor and age as a covariate was used for statistical comparisons. Speech-in-noise recognition was modelled using exploratory regression analysis.

Results: For group analysis, QERB estimates appeared to be similar between children with a documented history of OM and controls. However, 14 out of 76 had QERB estimates outside the 95% confidence interval of the controls for 2.282 kHz. Speech-in-noise thresholds were significantly poorer for children with documented OM history than age-matched controls. Further, these effects could not be attributed to potential middle ear pathology, as wideband absorbance was within normal limits at the time of testing. Exploratory regression analysis revealed QERB at 2.282 kHz and OM history to be determining predictors for speech-in-noise recognition.

Conclusions: Although group comparisons suggest that cochlear tuning estimates may not be altered in children with a documented history of OM, data suggest that cochlear tuning may be compromised in a small subset of children with resolved otitis media. This could highlight individual differences in the effect of OM on cochlear tuning. Model outcomes describing the relationship between resolved OM, cochlear tuning, and speech-in-noise recognition will be discussed.

Controlling for Auditory Abilities when Measuring Distraction: A Pilot Study

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Objectives: Although distraction has been widely noted as a challenge for children with hearing loss, it has not yet been evaluated for its contribution to communication outcomes of children with hearing loss. Event-related potentials (ERPs) can be used to measure the timing of multiple processes that result in behavioral distraction: (a) involuntary attention shifts to a distracting stimulus and (b) subsequent reorientation of attention back to the original task. Available ERP paradigms cannot be used with children who have hearing loss as they require in-tact auditory processing abilities. We developed a novel ERP paradigm that uses individually adapted stimulus parameters to control for developmental and hearing-related differences in auditory processing. The purpose of this pilot study was to use this novel paradigm in adult listeners to replicate previous findings that characterize the timing of attention shifts following auditory distraction when task instructions differ.

Design: Twelve young-adult listeners with normal hearing participated in an ERP study where stimulus characteristics were individualized to their frequency discrimination abilities. Participants were asked to discriminate frequency glides traveling upwards or downwards (50/50 probability). Eighty-five percent of stimuli were presented to the left ear (standards) and 15% presented to the left ear (deviant). In the 'Act' condition, participants were instructed to respond to all stimuli; whereas, in the 'Ignore' condition, participants were to only respond to stimuli in their left ear. Response times were used to measure the distraction effect (deviant minus standard) in the Act condition and residual distraction effects (first standard after a deviant minus standard) in both conditions. P3a and RON ERP responses were measured to represent the time-course of the involuntary attention shift to the deviant (P3a) and the disengaging of attention from the deviant and reorienting attention back to the original task (RON).

Results: Five participants failed to reach our criteria of 80% accuracy. Data from the remaining seven participants showed that, although distraction effects (direct and residual) were not observed in the Act condition ($p > .05$), a large residual distraction effect was present for the Ignore condition ($p = .012$). That is, response times to standard stimuli following deviants were >200 ms longer than baseline standard response times. Preliminary analyses of ERP data show robust RON responses, with small or absent P3a responses.

Conclusions: Preliminary findings suggest that the individually-adapted stimulus parameters employed in this paradigm successfully induced residual effects of distraction when participants were focused on ignoring deviants. Distraction effects were not observed with these stimuli when participants were actively engaged in processing the deviants. Although ERPs and behavioral data were broadly consistent with previous work, several notable differences (e.g., absent P3a responses) and the large percentage (41%) of participants who were unable to maintain performance in the ERP task with individually-adapted stimuli suggest that further research is required before this paradigm can be used to study attention in children with hearing loss.

Determining Air Bone Gaps at Extended High Frequencies

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Objectives: Measurement of bone conduction (BC) thresholds at extended high frequencies (EHF; above 8 kHz) is of clinical interest but has been infrequently performed due to standard transducer output limits and a lack of normative threshold data. We use the Tascam HP-F200 to determine EHF BC force thresholds in dB re 1μN in subjects with normal standard frequency (0.25-8kHz) hearing thresholds and compare BC thresholds with air conduction (AC) thresholds at identical frequencies.

Design: A prospective human subject study. Forty-six 'normal hearing' subjects with standard frequency air (AC) and bone (BC) conduction thresholds ≤20dBHL and ten subjects with a range of binaurally symmetric hearing pathology at standard frequencies were recruited for EHF AC and BC testing with Sennheiser HDA 200 earphones and a calibrated Tascam HP-F200, respectively. An audiologist obtained thresholds at EHF with AC in both ears and unilateral unmasked BC thresholds in the left or better hearing ear. Individual BC thresholds were converted from dB re 1μN to dB HL by normalization to

median BC thresholds from the 'normal hearing' group. Air bone gap (ABG) was calculated by subtracting BC thresholds from AC thresholds in HL.

Results: In the 'normal hearing' group, mean age was 28yrs (range 18-47) and 30 subjects (65%) were female. Many 'normal hearing' subjects had AC EHF hearing thresholds >20dB. Individual AC and BC thresholds increased in variability between subjects with increasing frequency. The median BC thresholds from our 'normal hearing' group set the following Reference Equivalent Vibratory Force Threshold Levels (REVFTL) in dB re 1μN: 40 dB at 8 kHz, 39dB at 9 kHz, 43dB at 10 kHz, 43dB at 11.2 kHz, 37 dB at 12.5kHz, 45 dB at 14kHz, 59 dB at 16kHz. Mean EHF air-bone gaps for the 'normal hearing' group were between 2 and 7dB, with interquartile ranges of +/- 5dB, suggesting air and bone thresholds track together. Subjects with standard frequency down-sloping sensorineural hearing loss (SNHL) had EHF AC and BC thresholds that were similar, indicating EHF SNHL. In a subject with bilateral 15dB mean standard frequency ABG, a 25dB mean ABG was found at EHF. In a subject who underwent bilateral stapedotomies with closure of the standard frequency ABG but elevated AC thresholds over 4kHz, a 40dB ABG was identified at EHF, suggesting conductive not sensorineural pathology at high frequencies after stapedotomy.

Conclusions: EHF BC thresholds can be measured using the Tascam HP-F200. The REVFTLs we defined in this small cohort were similar to previous studies. Further refinement of a 'normal hearing' population would better set REVFTLs at EHF. From our preliminary studies, we demonstrate the presence of high frequency air bone gaps, which suggests EHF conductive pathology in both diseased and reconstructed middle ears. Measurement of EHF BC thresholds may assist in differentiating etiologies of EHF hearing loss. Additional testing of EHF BC thresholds is needed in normal and pathologic ears.

Objective Assessment of Hearing Thresholds Based on Joint Swept-Tone DPOAEs and SFOAEs

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Objectives: This study aims to develop deep learning (DL) models for quantitative prediction of hearing thresholds based on the joint application of distortion-product otoacoustic emissions (DPOAEs) and stimulus-frequency otoacoustic emissions (SFOAEs) evoked by swept tones.

Design: A total of 96 ears with normal hearing and 300 ears with sensorineural hearing loss were studied. Both DPOAEs and SFOAEs in the 0.72-8 kHz frequency range were recorded using exponentially swept tones at a rate of 4 octave/s. The stimulus level varied from 20 to 70 dB SPL for DPOAEs and from 20 to 60 dB SPL for SFOAEs, with increments of 10 dB steps for both. Five convolutional neural network (CNN) based DL models were used to predict hearing thresholds at octave frequencies from 0.5 to 8 kHz. The inputs to the DL models were the measured raw OAE amplitude spectra and their corresponding signal-to-noise ratio spectra. The architecture of the models contains 2 convolutional layers, 1 global average pooling layer and 2 fully connected layers. Model performance was assessed using the mean absolute error (MAE) averaged over 10 repetitions of 6-fold cross-validation. The performance of the proposed DL models was compared with the traditional ML models.

Results: The proposed joint OAE-based DL models achieved optimal MAEs of 5.37, 3.95, 4.32, 5.37 and 5.77 at 0.5, 1, 2, 4 and 8 kHz, respectively, superior to that obtained by the traditional ML models.

Notably, all the DL models outperformed any hearing prediction model constructed in the previous studies.

Conclusions: The DL model proposed in this study, incorporating both DPOAE and SFOAE, demonstrates satisfactory performance in objectively and quantitatively predicting hearing thresholds. The use of deep learning technology enables the exploration and capture of relationships between various OAEs types and hearing thresholds at disparate frequencies, potentially enhancing the clinical utility of OAEs.

Neural Tracking of Speech and Environment with Multi-Modal Sensor Integration

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Objectives: When navigating everyday listening situations, the hearing-impaired face many challenges. A given environment may present different obstacles to successful communication, depending on the intention of the user in that specific environment. Entering e.g., a busy social scene, the user may first need to get an overview, and search for persons they seek to engage in communication with, requiring access to and evaluation of multiple streams of information. Subsequently engaging in conversation with a friend, the need is rather for assistance in a focused conversation. What counts as signals in the first situation may be perceived as noise in the next, depending on where the user wants to allocate their attention.Sensors registering communication events, acoustic environment, and changes in user behavior have been components in hearing aids for the past few years. The integration of such multimodal sensor information may reveal not only key characteristics of the listening environment that the user is situated in, but also the listening or communication intention of the user. This opens new possibilities for automatic adaptation of hearing aid signal processing to user intent.New technology developments now enable the use of multi-modal sensor integration (MMSI) to predict what the user needs in a communication situation and steer hearing aid processing to flexibly support the user's intention. Here we show how audiological help adapted to different user intentions impacts how speech targets and sounds in the environment are given access to the user's attention and related neural processing.

Design: Thirty participants with hearing impairment were listening to continuous speech targets (1-minute newsclips), while environmental sounds (e.g., kitchen or traffic noise, sounds from social activities, animal sounds, etc.) were presented from the sides and back, while being masked by static noise. Participants were equipped with hearing aids with the MMSI technology. During the experiment, steering of the audiological help was manipulated, so that the participants were either given audiological help on the assumption that they were either exploring a new environment, or engaging in focused listening or communication. We assessed how speech targets and sounds in the environment were acquiring differential access to attention. From the EEG signal, neural representations of the two stimulus classes were assessed with neutral tracking techniques, that are known to reflect allocation of attention. Speech comprehension was assessed with two comprehension questions following each 1-minute trial.

Results: Results showed that attention to and neural representation of the acoustic surroundings changed as the hearing aid was adapting to either a focused conversation or searching behavior. Attention to the speech target as well as speech comprehension remained constant.

Conclusions: This indicates that the MMSI technology may support differential allocation of attention and neural resources in users, depending on their need for e.g., searching a complex environment or engaging in focused listening.

Age-Related Changes to Binaural Hearing: Behavioral and Electrophysiological Indicators

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Objectives: Successful binaural hearing, particularly in noise, requires precise temporal encoding of auditory input along the auditory pathway. Unfortunately, binaural processing deficits can be reported even from aging listeners with normal hearing sensitivity and may present as difficulties understanding speech in noise, or localizing sound sources. To investigate these sub-clinical deficits, several auditory brainstem response (ABR) characteristics have been suggested as markers of synaptopathy and reduced cochlear function. Additionally, each ABR peak can be associated with a generator along the auditory brainstem. Neural measurements may highlight potential sites of dysfunction along the auditory pathway as previously evidenced by abnormal ABR waveforms observed from multiple sclerosis patients. We hypothesize that these age-related deficits may be caused by dysfunction along the central auditory pathway and that these subtle changes may be observed in both behavioral and physiological assessments. Age-related binaural hearing ability can also be impacted by factors such as cognition and noise exposure history.

Design: Data presented are part of a larger multi-year study examining the contributions of aging on the sound localization pathway. Inclusion criteria include subjects aged 21-89 years old, all with bilateral, normal hearing or only a mild hearing loss from 250-4000 Hz, inclusively. Exclusion criteria include mild or greater cognitive impairment, non-native English speakers, conductive pathology, and neurodegenerative disease. Eligible participants completed audiological testing including standard and extended high-frequency audiometry, QuickSIN, otoacoustic emissions, and tympanometry. Primary behavioral assessments include adaptive tests of spatial speech understanding in noise (SSIN) and spatial acuity in noise measured in a hemi-anechoic chamber, temporal fine structure sensitivity, and modulation sensitivity. Primary electrophysiological assessments include the auditory brainstem response for monaural and binaural stimuli and electrocochleography (ECOG). Participants also complete a working memory assessment as well as questionnaires assessing hearing ability and noise exposure. This subset contains selected measurements from 41 subjects aged 21-78 years old (24.4% male). All assessments are completed within 5 sessions at the University of Colorado Anschutz Medical Campus auditory lab.

Results: Results obtained to date indicate significant negative effects of aging on spatial speech in noise understanding and electrophysiological measures despite normal-mild hearing thresholds through 4 kHz. Significant relationships are observed from correlations between SSIN and several ABR characteristics,

including proxies of age-related cochlear synaptopathy (e.g., Wave I Amplitude, I/V Ratio) and Wave III amplitude which may suggest reduced input to the binaural brainstem. In contrast, behavioral measures did not significantly correlate with ECOG. Potential confounding factors such as higher frequency hearing, working memory, subjective hearing ability, and their interactions, will also be examined.

Conclusions: Age-related changes can be observed from each of our auditory assessments despite reported 'good' hearing ability and normal to mild hearing loss through 4 kHz. Standard speech in noise assessments may not be sensitive to subtle age-related changes and additional testing should include more adverse listening conditions and spatially separated stimuli. Relationships between behavioral and electrophysiological measurements suggest there may be multiple sources of dysfunction and/or poor encoding at the brainstem that may be contributing to functional hearing deficits. [Support: NIH-NIDCD R01 DC017924 (PIs: Tollin & Klug)]

Associations of Primary Spoken Language with Individual Perception of Hearing-Related Disability

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Objectives: Hispanic/Latinx adults, are less likely than non-Hispanic White adults to seek treatment for hearing disability despite similar degrees of hearing loss. While differential socioeconomic factors may contribute to this finding, differences in phonology and syntax in the Spanish, versus English, language may also influence patient perception of hearing disability. Furthermore, it has been demonstrated that bilingual patients are more likely to qualify for cochlear implantation when tested in English than they were when tested in Spanish. These observations may be explained by inherent differences in language syntax and the presence of more high-frequency phonemes in the English language. Given that hearing loss often first presents in high frequencies, these differences inherent to the Spanish and English languages may have a significant impact on relative patient performance on audiometric testing when conducted in Spanish versus English. This study aims to better understand how primary spoken-language is associated with patient-centered metrics for assessment of hearing-related disability which may mediate patient treatment-seeking behaviors.

Design: This study represents a cross-sectional cohort study using National Health and Nutrition Examination Study [NHANES] data. Multivariable logistic regressions estimated the association between respondent-selected interview language and participant perception of hearing disability. Models were adjusted for age, gender, highest degree of education, pure tone average, and self-reported general health. Participants included 4,695 individuals from the United States population who elected to speak English (n=4,091) or Spanish (n=604) during the interview. Perception of hearing-related disability was assessed by participant responses to a hearing focused questionnaire.

Results: Speaking Spanish as a primary language was associated with a 42% reduced odds of reporting difficulty hearing and understanding in background noise (OR 0.58, 95% CI 0.48-0.70). Spanish speakers

had a 28% reduced odds of reporting feeling frustrated when talking to family members or friends due to hearing (OR 0.72, 95% CI 0.59-0.88) as compared to the English-speaking cohort. Speaking Spanish additionally conferred a 31% reduced odds of describing a participant's own general hearing as "a little trouble to deaf" than participants speaking English (OR 0.69, 95% CI 0.53-0.90). These observed associations were independent of age, gender, highest degree of education, better hearing or pure tone average, and self-reported general health.

Conclusions: Primary Spanish speakers may be less likely than English speakers to report hearing-related disability which may impact patient behaviors in seeking treatment. Patient perception of hearing loss should be considered an important factor in determining appropriate treatment plans. This study serves as a call for improved understanding of the language- and culturally-mediated differences in the lived experiences of our diverse patients with hearing loss, and for more study of diagnostic audiometric protocols that better incorporate primary spoken language and quality of life metrics.