American Auditory Society Scientific and Technology Meeting
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PODIUM SESSION I: AUDITORY / VESTIBULAR PHYSIOLOGY

Changing Relationships between Stimulus-Frequency and Distortion-Product OAEs during Aging

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There are two broad classes of otoacoustic emissions (OAEs): those that are created by nonlinear distortion and those created by cochlear reflections. The two classes are sensitive to distinct cochlear properties, provide non-redundant information about hearing, and offer the potential for differential diagnosis. Here, we applied a dual-OAE approach to study aging. Based on past work (Abdala and Dhar, 2012), we hypothesized that aging produces added irregularity or 'roughness' along the cochlea-a known source of back-scattering and reflection-which results in the generation of atypically robust reflection OAEs during senescence. To study possible changes in the relationship between stimulus-frequency (reflection) and distortion-product (distortion) OAEs (i.e., SFOAEs, DPOAEs) during the human lifespan, we recorded both in subjects ranging from 18 to 76 years old at multiple stimulus levels across a four-octave range. Our results confirm that aging impacts reflection and distortion OAE levels differently: SFOAE levels are relatively preserved compared to DPOAE levels during advancing age. This finding, which is most evident at low-to-mid frequencies, persists even when controlling for hearing loss. Modeling and OAE simulations suggest that increased roughness in the aging cochlea could produce the observed result. The clinical implications of this finding will be explored.

Influence of High Sound Exposure on Wave I Amplitude in Collegiate Musicians

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Objective: The purpose of this study was to determine whether the expected loud music exposure among student musicians with normal hearing thresholds is associated with reduced amplitude of auditory brainstem response (ABR) wave I. Design: Two-channel ABRs responses were recorded from left ear: one channel utilized an ipsilateral mastoid electrode and another channel utilized an ipsilateral tiptrode. Click evoked ABRs were collected at 90, 75, and 60 dB nHL. A mixed design was used to study the main effects of group, electrodes, stimulus levels, and the interaction between these variables. Study sample: 75 collegiate students were recruited from a university campus and were grouped into a non-musician group (n=25), a brass major group (n=25), and a voice major group (n=25). All the participants were screened for noise exposure, hearing, and middle ear function. Results: The average amplitude of ABR wave I was significantly reduced in the brass and voice major groups, compared with the non-musicians group. The reduced

amplitude of ABR wave I in the musician groups is indicative of damaged afferent nerve fibers (ANFs) innervating inner hair cells. These ANFs with high thresholds and low spontaneous rates are important for detecting signals in the presence of noise.

Estimating Audiograms from the ABR for Infant Hearing Aid Fittings

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Best practice in early hearing detection and intervention (EHDI) programs indicates the use of auditory electrophysiological measures, such as frequency-specific auditory brainstem response (ABR), for infant hearing assessment. ABR enables prediction of audiometric thresholds to determine hearing status, hearing aid candidacy, and to compute hearing aid prescriptive targets. Corrections are commonly applied to ABR thresholds for improved accuracy of the predicted audiogram and appropriate subsequent intervention activities. The EHDI program in Ontario, Canada has adopted several correction factors over the years. The results of a series of research activities to better document and understand the performance of existing corrections and future protocols will be presented. In addition to a comprehensive literature review, clinical files of infants from three Ontario EHDI sites are being reviewed. Hearing assessment data from ABR and subsequent behavioural audiograms are being gathered from infants with varying degrees and configurations of hearing loss. Comparing these will assess the accuracy of current ABR corrections. Additionally, laboratory and clinical data collection is underway to evaluate ABR collection parameters such as stimulus type, participant age, calibration requirements, hearing levels, and system type, and their impact on the correction. Results and considerations will be consolidated for application into clinical practice.

Toward A Clinical Test Battery for Cochlear Synaptopathy

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Jeffrey Danhauer, PhD, University of California Santa Barbara, Goleta, CA
Richard Kopke, MD, Hough Ear Institute, Oklahoma City, OK

Background Information: Cochlear synaptopathy (CS) is early damage to inner hair cell ribbon synapses with nerve fibers, not seen on routine audiometric tests. Purpose: Report on development of a test battery for CS. Research Design: Group design. Study Sample: 60 normal-hearing adults (M age = 22 years); 30 low-risk, 30 high-risk (musicians) for CS. Data Collection and Analysis: Participants underwent audiologic evaluations and completed tests: ultra- high-frequency audiometry, speech recognition in noise and/or temporal distortion (accuracy and listening effort for QuickSIN and the Edgerton-Danhauer NST [T = 1.0; +10 dB S/N]), Acceptable Noise Level, Gaps-in-Noise, Masking Level Difference, DPOAE, ECochG (SP/AP ratios obtained with tiptrodes), and ABR (Amplitude

Wave I). Participants also completed questionnaires: (1) Hearing Health and Personal Characteristics, (2) Experiences and Abilities in Different Listening Situations, (3) Loudness/Annoyance of Sounds and Hyperacusis (Liberman et al, 2016), and (4) the Tinnitus Handicap Inventory. Results: Some statistically, but no clinically significant group differences were found. Quality control algorithms were developed and implemented for SP/AP ratios and ABRs. Conclusions: Test results for these young adults at high-risk for CS were not clinically significantly different from low-risk peers indicating need for further test development. (Funded by the Hough Ear Institute)

Combined Imaging and Electrophysiology After Cochlear Implantation Assess Neural Integrity

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Electrically-evoked auditory brainstem responses (eABRs) measured after cochlear implantation can provide information about neural excitability. Using two datasets, we show that combining electrophysiological and imaging measures can provide insights into neural excitability and that this can predict CI mapping at switch-on. In individuals with structurally normal cochleae, we compared eABR wave V (eV) amplitudes at 3 electrode positions (basal; electrode 3), mid (electrode 11), and apical (electrode 20) for individuals with a Cochlear Straight array (n=25) and a Cochlear Contour array (n=25). Using imaging to determine the positioning of the basal part of the electrode array in the cochlea, we classified insertions into 'scala tympani (n=97)', 'scala vestibuli (n=5)' or 'translocated (n=3)'. Wave V amplitudes were compared with mapping parameters at cochlear implant 'switch-on', 4-weeks and 12 weeks across all 22 electrode sites. A significant difference was found in eV amplitudes for straight and countour arrays. Further, a strong correlation was found between eV amplitudes and CI mapping parameters (T- and C-levels) at switch-on, which became less strong over time. Results from the second study show that a strong correlation between eV mapping parameters for scala tympani insertion, but poorer correlations for scala vestibuli insertion or translocation.

Auditory Brainstem Response Signal-to-Noise Ratio of Tursiops Truncatus

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We recently investigated the effects of click rate on auditory brainstem responses (ABRs) of the bottlenose dolphin using conventional averaging, maximum length sequences (MLS) and randomized stimulation and averaging (RSA). Responses were observed at the highest rate used (1250 Hz) and ABR peak amplitudes decreased with increasing rate. For this presentation, we investigated the effects of click rate on the residual noise and signal-to-

noise ratio (SNR) of the ABR. The ABR was obtained in six dolphins (three dolphins with the full range of hearing; three dolphins with a high-frequency hearing loss). Click level was 135 dB peSPL (re: 1 Pa). Conventional rates included 25 and 100 Hz, and MLS/RSA rates ranged from 100 Hz to 1250 Hz. Residual noise was assessed over time using 3 methods: single-point noise estimation, plus/minus difference, and the rms of the average after the ABR had ended. For all approaches, residual noise typically decreased with increasing number of sweeps, but differences were found across approaches. Using the rms voltage of the ABR waveform, the SNR was calculated for MLS/RSA approaches across rate. The optimal stimulation rate will be discussed, and include factors such as noise estimation approach and normal-hearing versus hearing-impaired dolphins.

Calcium Dependent Activity in Gravity Receptor Pathways following Otolith Stimulation

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Manganese acts as a calcium surrogate, accumulating in active neurons, largely through voltage-gated calcium channels. As a paramagnetic agent, manganese serves as a contrast for magnetic resonance imaging (MRI). Thus, manganese enhanced MRI (MEMRI) can be used to assess calcium channel function and quantify neuronal activity. While several sensory systems are evaluated with MEMRI, studies of vestibular and balance pathways are limited. Short bursts of linear acceleration (jerks) known to stimulate otolith organs and produce short latency vestibular evoked potentials (VsEPs), were used to assess manganese uptake in central vestibular nuclei (lateral, medial, superior, and spinal vestibular nuclei) as well as related cerebellar nuclei in adult Sprague Dawley rats. Under normal, pre-stimulation conditions, significant manganese uptake is readily detected in central vestibular nuclei 24-hours after administration and returns to baseline levels within two weeks. In addition, there is differential manganese uptake in rats with jerk stimulation compared to those without. These results may provide important clues regarding mono and disynaptic excitatory and inhibitory inputs to central vestibular neurons and help to clarify contributions of central neurons to VsEP waveforms. In the future MEMRI can be used in longitudinal experimental designs to evaluate models of vestibular dysfunction.

PODIUM SESSION II: EPIDEMIOLOGY AND COGNITION

Cadmium and Lead and the 10-yr Incidence of Hearing Impairment

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Heavy metals such as cadmium and lead are known neurotoxins. The purpose of this paper was to determine if higher blood levels of cadmium or lead were associated with an

increased 10-yr risk of developing hearing impairment in the prospective Beaver Dam Offspring Study. Hearing thresholds were measured by pure-tone audiometry at baseline (2005-2008), five-year (2010-2013) and ten-year (2015-2017) follow-up examinations. Incident hearing impairment was defined as a pure-tone average > 25 dB HL at 500, 1000, 2000, and 4000 Hz in either ear. There were 1896 participants with normal hearing at baseline and blood cadmium and lead levels measured from stored baseline samples. The average age was 48 years (SD=9) and 43% were men. The cumulative 10-yr incidence of hearing impairment was 17.9%. Participants with the highest cadmium levels (quintile 5 > 0.53g/L) were more likely to develop hearing impairment than all others (adjusted Hazard Ratio (HR) = 1.58, 95% Confidence Interval (CI) 1.06, 2.37). There was no association between lead level and risk of hearing impairment (HR=1.05, 95% CI 0.77, 1.43). These data suggest that cadmium, but not lead, is associated with the risk of developing hearing impairment even at the low levels found in the general population.

Kids Nowadays Hear Better Than We Did

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If you were born between 1949 and 1958, you might have been one of the American youths (ages 12 - 17) whose hearing was tested in the National Health Examination Survey between 1966 and 1970 (n = 6768). In that survey, 3.3% of youths (95% confidence interval = 2.7 - 3.9) had better-ear (bilateral) speech frequency (0.5, 1, 2, and 4 kHz) hearing impairment (HI), defined as average threshold - 20 dB HL; 13.6% (12.1 - 15.2) had better-ear high-frequency (3, 4, and 6 kHz) HI. Later federal surveys (ages 12 - 19) showed much lower prevalences, with confidence intervals that did not overlap those for the 1966 - 1970 survey. In the National Health and Nutrition Examination Surveys of 1988 - 1994 (n = 3057) and 2005 - 2010 (n = 4374), better-ear speech frequency HI was found in 0.58% (0.32 - 1.06) and 0.77% (0.51 - 1.16) of youths, respectively; better-ear high-frequency HI was found in 1.64% (1.06 - 2.51) and 1.52% (1.11 - 2.09), respectively. Trends were similar for unilateral HI. In multivariate analysis for the most recent survey, significant risk factors for better-ear speech frequency HI were low birth weight, ear tube surgery, and use of firearms.

Prevalence and Factors Associated with Deafness or Serious Difficulty Hearing

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Hearing impairment is a worldwide societal and public health concern. In 2010, disabling hearing loss affected an estimated 538 million adults globally. Two nationally-representative cross-sectional surveys were analyzed: the 2014 National Health Interview Survey (NHIS) and 2016 Behavioral Risk Factor Surveillance System (BRFSS). Both surveys contained the same disability question on 'deafness or serious difficulty hearing' (D-SDH). Weighted prevalence, prevalence ratios, and 95% confidence intervals were calculated. Logistic regression was used to adjust for age, sex, race/ethnicity, education, income, and geographic region. Prevalence of D-SDH among adults aged 18+ years was 6.0% in the NHIS and 5.8% in the BRFSS. In both surveys, males had 60% higher prevalence. Prevalence was significantly associated with increasing age, lower educational level and income, and was higher for non-Hispanic whites than non-Hispanic blacks and Hispanics. The 2014 NHIS confirmed that D-SDH was strongly correlated with other responses reflecting the degree of self-reported trouble hearing. The BRFSS state-specific prevalences varied from 3.8%-13.3%, with higher prevalences in the most challenged states according to America's Health Rankings. The prevalence of D-SDH was approximately 6% in the NHIS and BRFSS, but increased considerably for older, less advantaged individuals and communities.

Epidemiology of "Hidden Hearing Loss"

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Introduction: Perceived hearing difficulty (HD) and/or tinnitus in the presence of normal audiometric thresholds present a clinical challenge, the most recent label to describe this phenomenon is 'hidden hearing loss'. Yet, there is limited data regarding prevalence and determinant factors contributing to HD. Methods: Here we review the literature and present estimates generalized to the non-institutionalized population of the United States based on the cross-sectional population-based study, the National Health and Nutrition and Examination Survey (NHANES) in 2,176 participants (20-69 years of age). Normal audiometric thresholds were defined by: pure-tone thresholds - 25 dBHL at 0.5, 1.0, 2.0, 4.0, 6.0, 8.0 kHz in each ear or pure-tone average (PTA4) of 0.5, 1.0, 2.0, 4.0 kHz - 25 dBHL in each ear. Hearing difficulty (HD) and tinnitus perception was self-reported. Results: Of the 2,176 participants with complete data, 1,177 had normal audiometric thresholds based on individual frequency and 2,015 based on PTA4. The prevalence of individuals with normal audiometric thresholds that self-reported HD was 10.4% using individual frequency criteria and 15% applying PTA4 criteria. The percentage of individuals with normal audiometric threshold and persistent tinnitus was 7.9% for individual frequency and 10.6% for PTA4 criteria. The overall sample (n = 2176) prevalence was 5.8% self-reported HD and 4.4% self-reported persistent tinnitus. Multivariate logistic regression adjusting for age, sex, and hearing thresholds identified the following variables related to increased odds of HD: tinnitus, balance issues, noise exposure, arthritis, vision difficulties, neuropathic symptoms, physical/mental/emotional issues; and for increased odds or reported persistent tinnitus: HD, diabetes, and analgesic use. Conclusions: The findings suggest that prevalence of HD is dependent on how normal hearing is defined and that

factors that impact odds of reported HD include tinnitus, noise exposure, mental/cognitive status, and other sensory deficits.

Cognition and Speech-in-Noise Performance: Population-Based Studies

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Speech-in-noise understanding entails bottom-up (peripheral hearing) encoding and top-down (cognition) decoding. Gaps in understanding cognition's contribution include the relative effects of different cognitive domains and how cognition impacts speech-in-noise performance over time. Here we present results from two lines of epidemiologic investigation: (1) cross-sectional contribution of domain-specific cognitive function to speech-in-noise performance in an observational cohort of 250 older adults, and (2) factors predicting baseline and 6-month change in speech-in-noise performance in 20 older adults with mild-to-moderate hearing loss who received hearing aids as part of a pilot randomized trial. In both studies, speech-in-noise performance was measured as signal-to-noise ratio loss using the Quick Speech-in-Noise (QuickSIN) test. In analyses adjusted for pure tone average (PTA), demographic and cardiovascular factors, better standardized cognitive performance in the domains of memory (=-0.77), language (=-0.92), executive function (=-0.60) and global function (=-1.08) were all cross-sectionally associated with better QuickSIN performance. In the second study (N=20), baseline cognition accounted for more variance in 6-month QuickSIN change than PTA or best-practice hearing aid fitting (partial R2 for global function=0.058, compared to 0.021 for PTA and <0.001 for fitting). Better understanding of cognition's contribution to speech-in-noise understanding could lead to precision-based audiologic intervention models.

Ears, Eyes and Mind: The SENSE-Cog Project

Harvey Abrams, PhD, Starkey Hearing Technologies, Lititz, PA

Mental, cognitive, vision and hearing health problems in elderly people are among the top 10 public health challenges in Europe. The European Commission, as part its Horizon 2020 program, funded the "SENSE-Cog Project" to better understand the inter-relationship between sensory impairments and cognitive and mental health functioning. The project is designed to identify novel screening and detection methods for diagnostic and therapeutic purposes and to translate this knowledge into clinical applications. This podium presentation describes the overall administrative structure of this multifaceted, interdisciplinary and multinational project as defined by its 6 work packages (WPs): exploration, assessment, intervention, participation, valuation, and management/governance/ethics. The presentation will focus on the intervention WP; specifically, the randomized controlled trial design as informed by a recently completed field trial - a single-arm, open-label field study across 3 clinical sites designed to assess the feasibility, acceptability and tolerability of a new sensory support intervention (SSI)

program for people with dementia (PwD) and concurrent hearing and/or vision impairment. The SSI is designed to offer PwDs with sensory impairment a period of sustained support delivered by sensory support therapists (SSTs) in the expectation of achieving positive, long-term changes in communication performance, cognition and quality of life.

The Aging and Cognitive Health Evaluation in Elders (ACHIEVE) Randomized Control Trial

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Theresa Chisolm, PhD, University Of South Florida, Tampa, FL
David Couper, PhD; Nancy Glynn, PhD, University of North Carolina Gillings School of Public Health, Chapel Hill, NC
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Novel approaches to reduce the risk of age-related cognitive decline, Alzheimer's disease, and other dementias in older adults are urgently needed given the aging population. Epidemiologic studies have demonstrated that hearing loss in older adults is strongly and independently associated with accelerated cognitive decline and incident dementia. Hypothesized mechanistic pathways underlying this association include the effects of poor hearing and distorted peripheral encoding of sound on cognitive load, brain structure/function, and/or reduced social engagement. Importantly, these pathways may be modifiable with comprehensive hearing loss treatment. ACHIEVE is a first-in-kind randomized trial to investigate the effect of a hearing rehabilitative program versus a successful aging program on rates of cognitive decline, incident dementia, physical and social functioning, and health-related quality of life. Eight-hundred-fifty cognitively normal, hearing-impaired adults aged 70-84 will be randomized 1:1 to a hearing program (needs assessment, fitting of devices, education/counseling) or successful aging program (individualized sessions covering healthy aging topics). This presentation will describe the design of the ACHIEVE study which began recruitment in 2017. Given that nearly two-thirds of adults aged 70+ have hearing loss, conducting the ACHIEVE study to determine if existing interventions can reduce the rate of cognitive decline is of substantial public health importance.

PODIUM SESSION III: HEARING ACROSS THE LIFESPAN

Age-Related Temporal Processing Deficits Revealed in Cortical Auditory Evoked Potentials

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Perception of degraded speech starts to decline in the fourth decade of life before audiometric hearing loss becomes clinically significant. Age-related declines in auditory temporal processing may contribute to impairments in speech understanding. Previous studies have shown that older adults have more difficulty discriminating between words that differ on the basis of temporal cues, such as phoneme duration. Yet, little is known about the neurophysiological mechanisms that contribute to these behavioral deficits. Therefore, we aimed to investigate age-related changes in temporal coding underlying phoneme identification of duration cues and to determine how well neural representation of these cues in the cortex can predict behavioral performance. We recorded cortical auditory evoked responses to naturally-produced words that differed in vowel duration (wheat vs. weed), and obtained perceptual identification functions from a 9-step vowel-duration continuum in younger and older adults. In older adults, P2 peak latencies were prolonged, suggesting an age-related delay in the process of auditory object identification. These delays were noted in the initial onset response and also in the second P2 peak associated with the stop consonant. No group differences were found in perceptual measures. This cortical investigation may identify auditory impairments that may not be revealed with behavioral measures.

Peripheral Auditory Aging in Humans: Different Measures, Different Perspectives

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Age-related decline of peripheral auditory function, typically examined using hearing thresholds, starts at high frequencies. We have recently completed an examination of this phenomenon using newly-developed test hardware and calibration techniques that allow accurate signal delivery up to 20 kHz. Results from over 1000 individuals (10 to 68 years) suggest an onset of age-related auditory decline starting in the high frequencies as early as the third decade of life with the most rapid decline occurring before the sixth decade. Distortion product otoacoustic emissions (DPOAEs) appear to be sensitive markers of these age-related changes, leading the decline in hearing thresholds by approximately five years. Interestingly, the profile of peripheral auditory aging captured by stimulus frequency otoacoustic emissions (SFOAEs) appears to be less sensitive than that observed using DPOAEs and hearing thresholds. SFOAE levels at low and mid frequencies show decline between the third and fourth decades of life, before plateauing at older ages. These aging and frequency differences in DPOAE and SFOAE behavior have to be interpreted after considering complications related to measurements, particularly those at high frequencies. Additionally, differences may point to the pathophysiology of auditory peripheral aging interacting with the processes responsible for DPOAE and SFOAE generation.

Ear-Canal Area Depends on Age and Gender: Applications to WAI Measurements

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Wideband acoustic immittance (WAI) measures depend on the ear canal's cross-sectional area; typically the reflectance is calculated with a constant. WAI and ear-canal area measurements were made on 171 subjects, with about ten female and ten male subjects in each decade of life from 20 to 80 years old and additional female subjects in their 20s. The ear-canal area was measured from a 3D scan of a silicone mold made in each ear canal. The area depended on gender and generally increased with age. For subjects in their 20s, females had a significantly smaller mean area than males (47.5 vs 53.7 mm^2); differences between female and male areas decreased with age and were only significant in the second and third decades of life. Females in their 20s had a significantly smaller mean area than females in their 70s (47.5 vs 70.1 mm^2); similarly, males in their 20s had a significantly smaller mean area than males in their 70s (53.7 vs 74.7 mm^2). Within the females in their 20s, there was not a significant difference in area between 17 Caucasian and 13 Chinese subjects. Reflectance measurements will be presented based on a constant value for area and using the measured values.

Cochlear Implantation in Young Children with Single Sided Deafness: Characteristics and Early Data

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Introduction: Treating children with substantial unilateral hearing loss (UHL) is typically limited to rerouting of signals to the better hearing ear. An ongoing clinical trial is evaluating whether young children with UHL experience an improvement in speech perception, localization, and quality of life (QOL) with cochlear implant (CI) use. The present report will review pre-operative findings and early outcome data. Methods: Children between 3.5-6.5 years with moderate to profound UHL were enrolled. The pre-operative test battery included pediatric and parental QOL questionnaires, speech perception, and localization assessment. These measures were repeated post-activation and localization testing was carried out with and without the CI. Results: Pre-operatively, subjects reported greater cognitive and general fatigue than their parents reported perceiving. Improvements in speech perception, localization, and QOL were demonstrated as early as 3 months post-activation. Conclusion: Children with UHL tend to perceive greater difficulty with fatigue than their parents' rankings would suggest. Early data suggests that CI use in children with substantial UHL provides improvements in speech perception, localization, and QOL, even within the early months of device use.

Phonetic Discrimination in Children Relates to Extended High Frequency Hearing

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Phonetic discrimination and reproduction has not previously been assessed using psychometrically robust methods or related to sensitive hearing measures. We report here results from 50 children; 38 with typical development (TD) and 12 with language impairment (LI) performing the American 'Listen-Say'. This assesses phonetic discrimination (PD) between and reproduction of CV minimal word pairs within five phonetic categories presented against quiet or speech shaped noise. Pure tone air conduction thresholds were obtained bilaterally at 1-16kHz using calibrated audiometer and circumaural earphones in a sound booth. TD children and LI children had high and comparable PD scores in quiet (TD, M=85.0%; LI, M=78.0%), with lower scores in noise (TD, M=66.3%, LI, M=61.0%). Reproduction of word pairs (TD, M=75.8%, SD= 23.2; LI, M=, 25.0%, SD=19.3) and number of reproduced words (TD, M=81.6%. SD=19.7, LI, M= 52.0%, SD=17.9) differed significantly between groups. For both groups, significant correlations were observed between PD accuracy in noise and EHF, but not lower-frequency thresholds. For children with LI, significant correlations were observed between reproduction accuracy and EHF thresholds of up to = - .57 (p = .02). These findings add to other evidence (Motlagh Zadeh, AAS, 2018) of the importance of EHF in hearing speech in noise.

Psychophysical Tuning Curves in Children and Adults with Differing Histories

Julie Arenberg, PhD; Lindsay Devries, AuD, University Of Washington, Seattle, WA

Cochlear implant (CI) programming techniques are based on data obtained in adult listeners, for whom the auditory system developed with normal input. These techniques have not been extensively studied in pediatric listeners, with consideration of their hearing histories. One factor that may reduce speech understanding, known as channel interaction, has not been evaluated in children. Channel interaction was assessed with psychophysical tuning curves (PTCs), and compared between children and adults. PTCs were measured for in 13 children, 10 of whom were sequentially bilaterally implanted (23 ears). The equivalent rectangular bandwidth (ERB) was used to quantify channel interaction. Although the mean ERB was similar between first and second implanted ears, the range was very large for the first implanted ear. PTCs were also obtained in 13 post-lingually deafened adult CI listeners. On average, adult ERBs were significantly narrower than those obtained in children, suggesting children may have more channel interaction. Participants performed a medial vowel identification task to evaluate the relationship between listening performance on a spectrally challenging task, age at implantation, duration of implant use, and PTC ERBs. Narrower ERBs were correlated with higher vowel identification scores. Children with later ages for the second CI tended to have wider ERBs.

Mobile Technology for Booth-Less Audiometry in Youth

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Increasing access to hearing health care to families with children will require the ability to conduct high-quality automated audiometry in diverse settings beyond the traditional audiology clinic. The test-retest reliability of automated thresholds (250-8000 Hz) were measured with a prototype noise attenuating, mobile, and wireless headset. Testing was conducted in typical environments where such tests might be conducted outside of a sound booth (physician's office, school, university clinic and health clinic). Tests were administered by untrained individuals such as nurses, parents and administrative staff. Forty one children (aged 6 to 15) were tested with the tablet controlled headset which also registered the listener responses. The median test-retest repeatability was 0 dB across all subjects and sites, with 25th and 75th percentiles within +/-5 dB. It was found that children under the age of 7 may require additional adaptation of the user interface to improve the use of the system, but most children reacted very positively to the technology. Listener and operator usability outcomes were positive. The results of this study demonstrate that mobile devices combined with noise attenuation can lead to the measurement of high quality audiograms in youth performed outside of the sound booth.

PODIUM SESSION IV: PROCESSING OF COMPLEX STIMULI

Speech-Evoked Envelope Following Responses Reveal Frequency-Specific Differences in Development

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Speech-evoked envelope following responses (EFRs) are proposed as an objective outcome measure in infants wearing hearing aids, based on promising findings in adults with hearing loss. However, little is known about the feasibility of this approach in infants. To this end, we aimed to characterize EFRs in normal hearing infants relative to young normal hearing adults. The token /susa'i/, spoken by a male, was used as the stimulus. Vowels contained low and mid frequency carriers, and fricatives were high frequency carriers. In adults (n=20) and one group of infants (n=21), the stimulus was presented at 65 dB SPL; the effect of the smaller infant canal on stimulus level was offset by correcting for real-ear-to-coupler differences (RECD). In the other age-matched infant group (n=23), the stimulus was presented without RECD corrections, and this provided a gain of ~15 dB in overall stimulus level. EFRs were recorded between the ipsilateral mastoid and high forehead. Compared to adults, infants showed (1) lower EFR and noise amplitudes, (2) similar detectability of high frequency EFRs but at higher stimulus levels, and (3) lower detectability of low frequency EFRs regardless of stimulus level. Results support slower maturation of low frequency-elicited EFRs compared to high frequencies.

Speech Recognition Performance in Older Spanish-English Bilinguals

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Younger bilinguals have been shown to have poorer speech recognition in noise performance than monolinguals (Mayo, Florentine & Buus, 1997). However, the effect of age on bilinguals speech recognition performance in their first and second languages remains unclear. Sixty adults (i.e., 15 Younger English Monolinguals, 15 Younger Spanish-English Bilinguals, 15 Older English Monolinguals, and 15 Older Spanish-English Bilinguals) participated in this study. Language proficiency was measured using the WoodcockMuoz Language SurveyIII (Schrank, et al., 2017) in English and Spanish. Monolinguals spoke English and bilinguals were early balanced Spanish-English bilinguals. Speech recognition was measured in quiet and in a speech-shaped noise using the English (Nilsson, et al., 1994) and Spanish (Soli, et al., 2002) Hearing in Noise Test (HINT). No significant ($p > .05$) group differences were observed in quiet. In noise, monolinguals performed significantly ($p = .001$) better on the English HINT than bilinguals. Bilinguals performed significantly better ($p < .001$) on the Spanish than English HINT, and younger bilinguals performed better than older bilinguals ($p = .02$). Younger bilinguals performed significantly ($p = .001$) better on the HINT in their L1 compared to all other groups. The implications of age and bilingualism on speech recognition will be discussed.

Use of Sentential Context During Recognition of Spectrally Degraded Speech

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Sentence context facilitates comprehension, particularly when listening to degraded speech. Consequently, cochlear implant (CI) users and normal-hearing (NH) individuals listening to spectrally degraded speech may rely heavily on sentential context. Moreover, evidence suggests that older listeners make greater use of context than younger listeners. This study examines the extent to which adult CI users (N=35), older adult NH individuals (mean age 70 years, N=35), and younger adult NH listeners (mean age 25 years, N=35) benefit from sentential context as a function of the quality of the sensory input. Additionally, we investigated how use of context relates to listeners' cognitive abilities. Participants were assessed in quiet for recognition of isolated words, meaningful sentences, and semantically anomalous sentences. CI listeners heard unprocessed speech; NH participants were tested using spectrally degraded versions (8-channel noise-vocoded). Participants also completed a battery of neurocognitive measures. Results demonstrated that the degree to which CI participants used sentential context depended on the quality of sensory input; this relationship differed for NH listeners compared to CI users and between older and younger NH listeners. Inhibitory control contributed in this process. Findings provide further evidence for the interaction of sensory and cognitive processing during speech recognition under degraded listening conditions.

Infants Use Visual Cues to Enhance Speech Perception in Noise

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Although infants are sensitive to the correspondence between auditory and visual speech cues, no previous studies investigated whether infants use this correspondence to improve speech perception in noise. This study used a modified observer-based psychoacoustic procedure to determine whether infants use visual cues to enhance speech detection and discrimination in noise. Adults and 6- to 8-month-old infants were trained to respond when they heard a CV syllable in noise (detection) or heard a change from the standard, repeated CV syllable in noise (discrimination). Participants were tested in auditory-only and audiovisual conditions. Although adults benefited more, both groups detected speech and discriminated consonants better in the audiovisual condition than the auditory-only condition. To determine what visual cues infants and adults used to achieve this benefit, a subset of participants completed testing in a third condition, in which the visual signal only cued the onset and offset of the auditory speech. This onset/offset cue accounted for detection benefit in both groups and for discrimination benefit in the infants. Results suggest that infants use onset/offset cues from visual speech to enhance speech detection and discrimination in noise. Adults - but not infants - rely on fine-grained visual details to further enhance consonant discrimination.

Extended High Frequency Hearing Contributes to Speech Perception in Noise

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Hearing loss is typically greatest at higher frequencies. Previously, we found that a remotely-deliverable, digits-in-noise (DIN) test may be sensitized for detection of high frequency hearing loss by low-pass filtering the speech-shaped masking noise. Participants in this study were 18-30 years old with tone thresholds 20 dB HL at 0.25-8kHz bilaterally. Extended high frequency (EHF) audiometry was also performed (10-16 kHz). DIN masking noise was presented 'broadband' (40dB down at 14 kHz) or with three different low-pass filters at 2, 4 or 8 kHz. As expected, the lower the frequency of noise filtering, the greater the benefit for speech detection in terms of speech reception threshold (SRT). However, two surprising results were found. First, 8/20 participants had an EHF hearing loss, mostly bilaterally and at 14-16 kHz. Second, even with the broadest filtered noise (<8 kHz), DIN SRTs were significantly more sensitive ($n=10$, $p<0.03$) than those obtained using broadband noise. This finding suggested that extended high frequency hearing contributes to performance of the normal DIN task. People complain of difficulty hearing in challenging environments, despite having normal audiograms. Our results suggest that one contribution to this difficulty, even for young adults, is an EHF hearing loss.

Sensing Real-World Environments with Hearing Aids to Understand Listeners' Perception

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It has been desirable for researchers and clinicians to understand hearing aid users' perception in different everyday environments, as this information may reveal opportunities to improve hearing aid troubleshooting and fine-tuning. The purpose of this study was to demonstrate the relationship between hearing aid users' perception and characteristics of the corresponding real-world environments. A smartphone/hearing aid-based Ecological Momentary Assessment (EMA) system was used. Specifically, hearing aids wirelessly streamed real-time data regarding environment characteristics (overall sound level and estimated signal-to-noise ratio [SNR]) to the smartphone. An EMA smartphone app initiated surveys for users to report their listening perception (speech understanding, listening effort, loudness, and speech-to-noise level). Data collected from 16 experienced users over 7 days showed that (1) although there was a wide range of everyday listening environments, objective data from the hearing aids and subjective data from the survey were generally consistent; (2) more speech understanding problems were reported in environments with higher overall sound levels; and (3) estimated SNR was weakly related to speech understanding and listening effort. The results suggest that hearing aids could be used as a sensor in conjunction with the EMA methodology to provide in-situ, real-time information regarding listening environments and listening experience.

The Development and Validation of the Speech Quality Instrument

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Brianna Griffin, MD, Stanford University, CA
Dean Mancuso, AuD; Stephanie Shiau, PhD; Ilana Cellum, AuD; Jaclyn Spitzer, PhD; Anil Lalwani, MD, Columbia University, New York, NY
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While speech perception tests are available to evaluate hearing, there is no standardized tool to quantify speech quality. The objective was to develop a validated tool to measure quality of speech heard. 35 normal hearing adults were recruited at a tertiary referral center. Participants listened to 44 speech clips of male/female voices reciting the 'Rainbow' passage. Speech clips included original and manipulated excerpts capturing goal qualities such as 'mechanical.' Listeners rated clips on a 10-point visual analog scale (VAS) of 18 characteristics (e.g. cartoonish, garbled). Skewed distribution analysis identified mean ratings in the upper and lower 2-point limits of the VAS; items with inconsistent responses were eliminated. The test was pruned to a final instrument of 9 speech clips clearly defining qualities of interest: speech-like, male/female, cartoonish, echo-y, garbled, tinny, mechanical, rough, breathy, soothing, hoarse, like, pleasant, natural. Mean ratings were highest for original female (8.8) and lowest for 'not speech' clips (2.1). Factor analysis identified two subsets of characteristics with excellent internal consistency (Cronbach's

alpha 0.95, 0.82). Test-retest reliability of total scores was high, with an ICC of 0.76. The Speech Quality Instrument (SQI) is a concise, valid tool for assessing speech quality as an indicator for hearing performance.

Do Earplugs Alter the Intensity or Dynamic Range of Music?

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Rationale and Professional Relevance: Some musicians may play the music louder or alter the dynamic range (DR) of music while using earplugs thus reducing the hearing protection or the music quality. In addition, cultural differences in attitudes towards loudness may lead to differences in the intensity of music played by musicians. Purpose: To investigate the effect of the use of two different types of earplugs on the loudness and DR of music played by musicians of Caucasian and Filipino origins. Methods: Fifteen musicians of Caucasian origin and 21 of Filipino origin played music in five different conditions: Trial one of conventional and musicians' earplugs, no earplug, and trial two of conventional and musicians earplugs. Maximum, minimum, average (LAVG) and peak levels were recorded using a dosimeter while playing music in each condition. The DR was derived from these values. Analyses: Mixed ANOVA (Cultural origin and Gender as non-repeated variables) was performed on LAVG and DR. Interpretation and discussion of results: There were main effects of culture and significant interactions involving cultural origin, the plugs versus no earplug conditions, type of earplugs, and trial number. Use of earplugs may vary the overall loudness of music and the DR in some musicians.

PODIUM SESSION V: HEARING ASSESSMENT & TINNITUS

Wideband Reflectance and Electrically Evoked Stapedial Reflexes Following Cochlear Implantation

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Absence of the electrically evoked stapedial reflex in ears with cochlear implants is often attributed to an increase in middle-ear stiffness following the surgery. This pilot study (1) characterizes middle-ear impedance using wideband power reflectance and (2) evaluates the use of a broadband probe for measuring the electrically evoked stapedial reflex in ears with cochlear implants. Standard 226-Hz and/or 678-Hz immittance measures will be provided for comparison. Preliminary results. Wideband reflectance: Within subjects, reflectance tends to be greater in the implanted ear compared to the non-implanted ear below 1000 Hz. At higher frequencies, systematic differences between implanted and nonimplanted ears are not apparent. Stapedial reflex: Stapedial reflex results provide proof of concept. Elicitor-evoked changes in reflectance patterns of the broadband probe are unique to the participant/ear, but tend to be greatest between 1000-3000 Hz. As the elicitor level is increased, the response grows; the response amplitude and growth rate are

variable across participants and electrodes used for stimulation. The use of a broadband probe will be compared to the traditional use of single-frequency probe tones. Implications for hearing preservation, for programming the electrical dynamic range, and for exploring the stapedial reflex as a diagnostic tool will be discussed.

Middle Ear Muscle Contractions are not Dependable Hearing Protection

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Decisions about the risk of hearing impairment from impulsive noise exposures are guided by Damage-Risk Criteria (DRC). Some DRC have invoked middle ear muscle contractions (MEMC) as a form of hearing protection, either as acoustic reflexes or in anticipation of imminent exposure. We report on the results from group of studies of (1) the prevalence of acoustic reflexes using clinical protocols, (2) the likelihood of observing MEMC for short-duration acoustic and non-acoustic stimuli among people with acoustic reflexes, and (3) attempts to train an anticipatory MEMC in lab environments. Numbers of participants in these studies ranged from 26 to well over 10,000 adults, with the greatest interest in individuals showing no signs or symptoms of abnormal hearing. Collectively, the results suggest that MEMC should not be included as protective factors in DRC for impulsive noises. Support for this study was provided by USAMRMC #W81XWH-14-2-0140 and CDC/NIOSH Contract # 200-2015-M-63121

Evaluating the Fixed-Level Frequency Test (FLFT) as a Clinical Measure of High-Frequency Hearing

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Marc Shapiro; Claire Healy; Odile Clavier, PhD, Creare LLC, Hanover, NH

Typically, routine audiometric examinations do not measure hearing at extended high frequencies (i.e. above 8 kHz), presumably because the additional time and special equipment required for high frequency testing is believed to outweigh any clinical benefit that can be obtained from this extra information. However, high frequency hearing can be clinically relevant and is known to be very sensitive to aging effects and ototoxic exposures. Recent results suggest that high frequency hearing loss may be implicated in some of the symptoms associated with auditory synaptopathy in otherwise healthy noise-exposed listeners. In our laboratory, we have been experimenting with the use of the Fixed-Level Frequency Test (FLFT), which uses Bekesy tracking to measure the highest audible frequency of an 80 dB SPL tone, as a rapid clinical measure of high frequency hearing. This assessment, which was originally developed as a screening method for otoxicity, can provide a reliable estimate of high frequency hearing in about 30 seconds. Here we present results on the reliability of the FLFT as well as information on how it correlates with

traditional audiometric thresholds and subjective and objective measures of speech-in-noise performance in normal and hearing-impaired listeners.

Use of Photovoice for Audiological Outcome Measurement and Rehabilitation

Gabrielle Saunders, PhD; Lauren Dillard; Melissa Frederick, AuD, National Center For Rehabilitative Auditory Research (NCRAR), Portland, OR

Photovoice is a qualitative method used for community-based participatory research to document and reflect reality with a view to developing solutions and programs to address social issues. In this study, we examined the application of photovoice as a clinical tool. Four pilot experiments were conducted. In Experiment 1, individuals with hearing loss took photographs of common situations in which they had trouble hearing to determine whether photovoice could be used to recommend situation-specific communication strategies and/or environmental adaptations. In Experiment 2, new hearing-aid users took photographs of daily activities in their hearing aids were particularly problematic or beneficial to determine whether photovoice could be used as a post-hearing aid fitting counseling tool. In Experiment 3, hearing-impaired individuals and their spouse/partner took photographs of typical shared daily activities in which communication was a problem to determine whether photovoice could be used to encourage discussion/problem-solving between spouses. In Experiment 4, hearing-impaired individuals took photographs showing what living with hearing loss meant to them to determine whether photovoice could provide an understanding of daily communication experiences and challenges. The results of these experiments will be presented and discussed, as will ideas for future photovoice research.

Tinnitus and Hidden Hearing Loss After Noise Exposure

Naomi Bramhall, PhD; Dawn Konrad-Martin, PhD; Garnett Mcmillan, PhD, Va Rr&d Ncrar, Portland, OR

Cochlear synaptopathy, the partial loss of auditory nerve synapses onto inner hair cells, has been proposed as a possible source of some forms of tinnitus. In animal models, cochlear synaptopathy is associated with a reduction in the amplitude of wave I of the auditory brainstem response (ABR) and can occur even when auditory thresholds are normal. This study assessed whether a history of noise exposure in young military Veterans and non-Veterans with clinically normal pure tone thresholds is associated with lower ABR wave I amplitudes and the perception of tinnitus. After adjusting for differences in sex and otoacoustic emissions, the groups with more noise exposure had smaller ABR wave I amplitudes compared to the groups with less noise exposure. Frequent or constant tinnitus was strongly associated with the highest noise exposure group. Tinnitus was also associated with reduced ABR wave I amplitude and elevated wave V/I amplitude ratios. Although post-mortem histological analysis would be necessary for confirmation, these data are consistent with animal models of cochlear synaptopathy and suggest that

synaptopathy or 'hidden hearing loss' may occur in response to high intensity noise exposure in humans and be correlated with tinnitus.

Electrophysiology and Behavior After Noise

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Sharon Kujawa, PhD, Dept. of Otolaryngology, Harvard Medical School; Eaton-Peabody Laboratory, Massachusetts Eye & Ear Infirmary, Boston, MA

Standard clinical methods for assessing noise injury are insensitive to diffuse loss of cochlear synapses and neurons, which raises significant challenges for diagnosing affected individuals and determining functional impacts. Here, we ask whether electrophysiological biomarkers of noise-induced synaptic and neural integrity developed in a mouse model provide evidence consistent with such loss in young Veterans and non-Veterans with normal auditory thresholds. We determine whether auditory brainstem response (ABR) wave I, a measure of the auditory nerve fiber group response, and the frequency-following response (FFR), a measure of neural encoding, correlate with noise exposure. Additionally, we characterize behavior using self-report (Tinnitus and Hearing Survey (THS), Spatial, Speech and Qualities of Hearing Scale-12 item (SSQ12)) and measures of speech perception (Quick-SIN, time-compressed speech, and speech spatial release from masking (SRM)) in order to gauge the impact of noise exposure history on auditory perception. Preliminary unadjusted results indicate a Veteran effect on electrophysiological measures. While Veterans express greater listening difficulty and more bothersome tinnitus, which we would anticipate to be related to neuronal loss, these deficits were not as evident on measures of speech perception. These results suggest there are functional consequences of neural degeneration associated with noise overexposure.

New Bimodal Neuromodulation Treatment for Tinnitus in 326 Patients

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Deborah Hall, PhD, University of Nottingham, Nottingham
Berthold Langguth, MD, University of Regensburg, Regensburg

There have been a wide range of novel sound and neuromodulation approaches for treating tinnitus. However, there still exists uncertainty as to which patients can benefit from different treatments and only a few confirmatory randomized clinical trials. Towards these needs, we performed an initial blinded and randomized clinical trial in 326 tinnitus patients to explore the therapeutic effects of bimodal neuromodulation, consisting of tongue and sound stimulation with our CE-marked device (MBT). We tested three MBT

algorithms (PS1, PS2, PS3) in various subgroups of patients across two clinical sites. Treatment was delivered for 12 weeks with a take-home device. Pre-specified outcome measures included the Tinnitus Handicap Inventory (THI) and Tinnitus Functional Index (TFI). All MBT paradigms resulted in statistically and clinically significant improvements in THI and TFI, which occurred rapidly within 6 weeks and continued beyond 6 months for many patients. There was high treatment compliance (85%) and no reported safety issue. In tinnitus patients with reduced sound tolerance, PS1 achieved significantly better outcomes compared to PS3, revealing specific parameters effective in a subtype of tinnitus patients. These findings provide critical information for guiding a multi-site confirmatory clinical trial (further protocol details in D'Arcy et al., BMJ Open 7(10):e018465, 2017).

Audiologic Management of Patients Reporting Tinnitus

James Henry, PhD, Va Rr&d National Center For Rehabilitative Auditory Research, Portland, OR

Audiology graduate programs are inconsistent in their provision of instruction regarding tinnitus management. Most programs provide minimal if any instruction. Audiologists, however, encounter patients complaining of tinnitus almost daily. This presentation will focus on evidence-based procedures for tinnitus management that can be conducted by any audiologist with relatively little impact on their normal clinical function. A clinical algorithmic protocol will be described. Tinnitus questionnaires are essential if tinnitus-specific intervention will be performedÂ¿to obtain a baseline assessment of tinnitus impact and to assess outcomes of the intervention. However, for evaluating any patient who reports tinnitus, the initial tinnitus assessment should be limited to using a questionnaire that clearly distinguishes between a tinnitus problem and a hearing problem. One such questionnaire exists (Tinnitus and Hearing Survey), which can be used with a routine audiologic assessment to determine if tinnitus-specific intervention is needed. Tinnitus psychoacoustic testing is not normally recommended. Research has demonstrated the effectiveness of hearing aids and combination instruments (amplification and sound generator combined). Brief tinnitus counseling can also be effective. Tinnitus outcome questionnaires should only be used if tinnitus-specific intervention will be provided beyond these basic services.

PODIUM SESSION VI: AUDITORY PROSTHESES

Further Evaluation of a Consumer-Decides Hearing-Aid Provision Model

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We recently published a double-blind placebo-controlled randomized clinical trial comparing two service-delivery models: audiology best practices (AB) and consumer-decides (CD). The CD model was designed to mimic one way in which over-the-counter (OTC) hearing aids might be delivered to consumers in the future. Because of the experimental nature of the clinical trial and the state of knowledge at the time of trial

initiation, we provided complete audiological evaluations to all participants prior to random assignment to the AB or CD groups. Further, because there was a third parallel branch of the trial, AB with placebo devices, placebo devices were not included in the CD branch. The current follow-up study explores the impact of both factors on outcomes in 35 new CD participants. These CD participants were not audiologically evaluated prior to participation and they also had a zero-gain placebo device as one of the options among the devices from which they could choose. We report the percentage of those who enrolled with 'red flag' conditions, based on follow-up evaluation, and who selected placebo acoustically transparent devices for themselves. Outcomes are also compared to the results from the prior study. (Work supported, in part, by a research grant from the NIDCD.)

An Observational Approach to Understanding Hearing Aid Success

Kelly Tremblay, PhD; Michael Lee, PhD, University Of Washington, Seattle, WA
Ruth Bentler, PhD; Yu-hsiang Wu, PhD; Christi Miller, PhD; Elizabeth Stangl, AuD, University Of Iowa, Iowa City, IA

Here we describe an observational and population approach to understanding subjective and objective contributions to hearing aid (HA) success. We conceptualize the HA user as a whole to define HA success, and therefore use a theoretical framework that includes acoustics, psychology and biology to reach this goal. Participants were 179 adult hearing aid users, age range (21-79 years) with mild to severe hearing loss. To help define what makes a person a successful hearing aid user, using their own personal hearing aids, person- and device- centered variables, were collected. Some include: acoustic analyses of hearing aid input-output characteristics, speech perception and personality measures, self-reported handicap measures, and EEG. A brief overview of initial findings, related to defining hearing aid success, will be discussed; as will the shared database that accrued. The contents of the database will be described so fellow investigators can become aware of the opportunity to participate in secondary data analyses. (Funded by NIH 5R01DC012769-04 awarded to KT and RB).

Re-Routing Options for Overcoming Severe-to-Profound Unilateral Hearing Loss in Classrooms

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Severe-to-profound unilateral hearing loss can have significant negative consequences for children. Although communication might be easy in some situations (e.g., in quiet), difficulties arise in complex listening situations, such as classrooms. Current amplification options for these children in classrooms include contralateral routing of signals and remote microphone systems. Both types of systems are designed to improve access to sounds by overcoming the head shadow effect (contralateral routing) or improving the overall signal-

to-noise ratio (remote microphone). Early research indicated remote microphones provided the most consistent benefits. However, this work was limited to speech originating from the front hemisphere. In typical classrooms, desired speech originates from many directions and speakers. The purpose of this study was to investigate re-routing amplification options for overcoming severe-to-profound unilateral hearing loss in a simulated classroom. Twenty school-aged children completed speech recognition and story comprehension tasks at a signal-to-noise ratio reflective of typical classrooms. Speech signals originated from loudspeakers in the front of, side of, and behind a listener. Collapsed across loudspeaker locations, performance with the remote microphone system was the most variable. The contralateral routing system provided the most consistent benefits. These findings have implications for clinical management of children with severe-to-profound unilateral hearing loss.

Advanced Digital Hearing Aids and Mild Loss: Outcomes and Self-Efficacy

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Jeffrey Danhauer, PhD; James Connor Sullivan, University of California Santa Barbara, Goleta, CA

Background Information: Little evidence is available regarding outcomes of advanced digital technology (ADT) hearing aid wearers with mild sensorineural hearing loss (MSNHL). Purpose: Report characteristics of and outcomes for this population. Research Design: Cross-sectional. Study Sample: 56 patients (private practice). Data Collection and Analysis: The International Outcomes Inventory for Hearing Aids (IOI-HA), Satisfaction with Amplification in Daily Life (SADL), and the Measure of Audiologic Rehabilitation Self-Efficacy for Hearing Aids (MARS-HA) were completed, scored, and compared to normative data. Results: ADT aids were worn 10.5 hours/day, were mostly advanced-to-premium (55%), cost M = $2138; SD = $840), and provided significant benefit (IOI-HA overall score M = 4.1; SD = 0.6) and satisfaction (SADL global score M = 5.4; SD = 0.8) to users who had good overall self-efficacy (MARS-HA composite score M = 81.7; SD = 12.8). Patients were most dissatisfied with and had the least self-efficacy for managing background noise and advanced handling of their devices. Conclusions: ADT hearing-aid users with MSNHL achieve excellent outcomes, but ongoing follow-up and counseling from hearing healthcare providers is essential for successful management of background noise and mastery of advanced handling skills.

Open Portable Platform For Hearing Aid Research

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Caslav Pavlovic; S.R. Prakash; Zezhang Hou, Batandcat Corporation, Palo Alto, CA
Tobias Herzke; Paul Maanen, HrTech gGmbH, Oldenburg

The NIDCD has recently funded a number of projects to develop portable signal processing tools that enable real-time processing of the acoustic environment. The overarching goal is to provide a large group of researchers with the means to efficiently develop and evaluate, in collaborative multi-center environments, novel signal processing schemes, individualized fitting procedures, and technical solutions and services for hearing apparatus such as hearing aids and assistive listening devices. We report on the specific goals and results of two such projects. In one of them (R01DC015429) an open source software platform for real-time runtime environments is developed: The open Master Hearing Aid (openMHA). It provides an extendible set of algorithms for hearing aid signal processing and runs under Linux, Windows and Mac operating systems on standard PC platforms and on small-scale ARM-based boards. An optimized version of openMHA is provided for the companion SBIR project (R44DC016247), which is a portable, rigid, versatile and wearable platform featuring an ARM Cortex-A8 processor. The resulting Portable Hearing Aid Community Platform consists of both hardware elements to provide the advanced desired functionality and software routines to provide for all the features that researchers may need to develop new algorithms.

Utilizing 3D Scanning Techniques to Investigate Ear Canal Dynamics

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Brian Fligor, Lantos Technologies, Woburn, MA

Many users of deeply-fitted custom hearing devices may experience discomfort and/or poor fit which require remakes. A primary reason for this may be attributed to the impression-taking method used to fit these devices. Conventional silicone impression-taking methods are typically used, however they have known limitations, including inaccurate representations of ear canal anatomy and dynamics. Alternative methods of obtaining more information about the ear canal anatomy and dynamics without requiring multiple physical impressions are desired. A study of 3D ear canal scanning techniques and computed tomography (CT) imaging was conducted to 1) determine their utility for capturing ear canal dynamics and 2) to compare the scans/images obtained to conventional silicone ear impressions. Results suggest scanning methods are clinically viable and can capture information about ear canal dynamics that may not be easily obtained with conventional silicone impression taking methods. These techniques may help inform decisions for custom ear device development and may help overcome current challenges with custom device fittings.

Singing with Cochlear Implants

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Although many cochlear implant (CI) users have a desire to sing, they often report having considerable difficulties singing. This may reflect difficulties controlling their vocal pitch,

maintaining appropriate pitch contours, or, for bilateral CI users, reconciling the different pitches perceived by their two ears. To examine these possibilities, eight bilateral cochlear implant users were asked to sing "Happy Birthday" when using their left CI, right CI, both CIs, and neither CI. The participants had considerable vocal pitch instability within individual notes. However, most participants largely followed the correct pitch contour. The pitch contours when singing with their left or right CI on were generally highly correlated, although the exact frequency of each note differed depending on which device they were wearing. Interestingly, the pitch contours for the two unilateral conditions were more similar to each other than they were to those for the bilateral condition. These results suggest that CI users have considerable difficulty correcting for small deviations in vocal pitch, but may be more able to control larger changes in vocal pitch, as occurs across notes. Additionally, the results suggest that differences in perceived pitch in the two ears may interfere with singing compared to using one ear alone.

Are the Noisier Speech Regions the Most Detrimental to Intelligibility?

Frederic Apoux, PhD; Brittney Carter; Karl Velik; Eric Healy, PhD, The Ohio State University - Wexner Medical Center, Columbus, OH

A fundamental property of the auditory system is to decompose sounds into a matrix of time-frequency (T-F) units. Accordingly, speech recognition in noise may be viewed as a classification problem, in which the auditory system must select a subset of T-F units to build a representation of the signal. Prior work has sought to establish the 'local criterion,' i.e., the signal-to-noise ratio (SNR) below which T-F units no longer contribute to overall intelligibility. Here, a technique is introduced that allows the 'weight' that each unit has on intelligibility to be estimated based on its SNR. Contrary to current understanding, we postulate that units with approximately equal target and noise energy (i.e., 0 dB SNR) are the most detrimental because these units are more ambiguous and therefore should be the most difficult to classify. This postulate is verified in normal-hearing subjects listening to unprocessed and vocoded sentences presented in a competing-speech background. The inclusion of a vocoded condition is motivated by the prospect to improve speech intelligibility in noise for CI users by removing only those ambiguous units. In contrast to noise-reduction techniques, the above approach may allow for the improvement of speech intelligibility in noise without suppression of the background.