

# American Auditory Society Scientific and Technology Meeting March 5-7, 2015

## PODIUM PRESENTATIONS: Thursday, March 5, 2015

### PODIUM SESSION I: SPEECH PERCEPTION; VESTIBULAR

#### Podium Paper I.A.

##### **Lost in Noise: A Journey to Find the Speech - A Tribute to Dr. Richard Wilson's Research on Speech Perception**

*Rachel McArdle, PhD, University of South Florida, Tampa, FL*

Richard Wilson is a well-known researcher with numerous publications in multiple areas of audiology. This talk will highlight the research he has published over the last 15 years focused on speech perception in noise by listeners with hearing loss as well as his role as a mentor to young investigators. Data from multiple studies will be presented and reviewed to support Dr. Wilson's statement that speech in noise testing should be thought of as an auditory stress test.

#### Podium Paper I.B.

##### **Effects of Developmental Factors on Spectral Resolution and Speech Recognition**

*Benjamin Kirby, PhD; Meredith Spratford, AuD; Ryan McCreery, PhD, Boys Town National Research Hospital, Omaha, NE*

The relationship between spectral resolution and adults' speech recognition in noise has been studied. To examine how spectral resolution relates to speech recognition in children, it is necessary to control for the influence of developmental factors on spectral ripple discrimination. It was hypothesized that age, memory, and executive function would be significant predictors of both ripple discrimination performance and speech recognition in noise; ripple discrimination, number of key words, and sentence predictability were also hypothesized to be significant independent predictors of speech recognition in noise. Young listeners with normal hearing (N=22, mean age=8 years 10 months, range=6-12 years) completed measures of 1) speech recognition in noise (with sentence predictability and number of keywords as within-task factors, 2) visuo-spatial processing and working memory, 3) executive function/attention, 4) expressive vocabulary, and 5) spectral ripple discrimination (with 1st vs. 2nd repetition as a within-task factor). Age, sentence predictability, number of keywords, and attention were significant predictors of speech-in-noise performance. Ripple discrimination was not a significant predictor of speech-in-noise performance in this group of children with normal hearing. Age and repetition were significant predictors of ripple discrimination. How these measures could be implemented in future studies with children who are hard-of-hearing will be discussed.

#### Podium Paper I.C.

##### **Objectively- and Subjectively-Measured Speech Understanding With Increasing Postural Instability**

*David Downs, PhD, Department of Communication Sciences & Disorders, Wichita State University, Wichita, KS*

In two prospective, within-subject experiments, we investigated effects of gradually increasing postural instability on objective and subjective measurements of speech understanding for two groups of 24 young adults with normal hearing, vision, and vestibular function. During both experiments, participants listened to lists of BKB-SIN Test sentences through a loudspeaker at a normal conversational speech level. During a single-task Experiment I, participants repeated sentences under four conditions: blindfolded or not blindfolded while sitting or standing in a simple Romberg posture. During a dual-task Experiment II, participants repeated sentences as a secondary task, while completing a primary task that emphasized maintaining balance under four conditions: blindfolded or not blindfolded while standing in a simple or sharpened Romberg posture inside a walker. Instability in Experiment II was measured as number of times participants touched the walker to maintain balance. After each experiment, participants also ranked relative difficulty of understanding sentences among the four conditions. For both experiments, participants showed no statistically significant differences among conditions on the objective measure of repeating sentences correctly; but they subjectively ranked speech understanding significantly harder for postures causing greater instability. These findings have implications for spoken communication of adults prone and not prone to balance problems.

#### Podium Paper I.D.

##### **Preschool children with hearing loss: real-time processing of audiovisual speech**

*Tina Grieco-Calub, PhD, Northwestern University, Evanston, IL*

*Janet Olson, PhD, Northern Illinois University, DeKalb, IL*

Sensitivity to visual speech cues varies during childhood: preschool-aged children are less sensitive than infants and older children. Chronic degradation of auditory input due to hearing loss in infancy, however, may shape children's sensitivity to visual speech. To test this prediction, we are using an eye-tracking paradigm to quantify the speed of speech processing (reaction time, RT) in two groups of preschool-aged children (30-48 months old): children with normal hearing (NH) or with bilateral sensorineural hearing loss (HL). Each child participates in four test conditions: quiet or with a speech competitor (+10 dB signal-to-noise ratio), with or without visual speech cues. With auditory-only cues, the NH group has faster RTs than the HL group in quiet. The addition of visual speech cues slows RTs in NH children but not in children with HL. The presence of the competitor slows RTs in both groups of children. The addition of visual cues in the competitor condition has variable effects: visual cues benefit children who have slower RTs in the auditory-only condition. These data suggest that auditory deprivation early in life may influence sensitivity to audiovisual speech. Discussion will include ongoing analyses of audiovisual speech perception in preschool children. [Funded by NIH-NIDCD 1R15DC011605]

#### Podium Paper I.E.

##### **Evaluation of Charge Levels on Postoperative Hearing Preservation**

*Margaret Dillon, AuD; Andrea Bucker, University Of North Carolina At Chapel Hill, Chapel Hill, NC*

The utilization of combined electric and acoustic stimulation (EAS) in an ipsilateral listening condition is dependent on postoperative hearing preservation in the surgical ear. Some subjects experience a decrement in residual hearing during the initial postoperative time period. Studies have also documented the progression of hearing loss in the implanted

ear for some recipients over time. The goal of this study was to assess the potential relationship between charge levels associated with electric stimulation and postoperative hearing preservation. Twenty-nine (29) adult subjects participated in the EAS clinical trial at the study site. Test intervals included: preoperative, initial cochlear implant activation, initial EAS activation, and 3-, 6-, and 12-months post-initial EAS activation. Unaided air- and bone-conduction thresholds were assessed bilaterally at each interval prior to mapping. Charge levels associated with the familiar map were compared to the change in residual hearing thresholds between intervals. Charge was not predictive of postoperative hearing preservation. In this cohort, charge levels were not predictive of postoperative hearing preservation. Further investigations are needed into potential influences on the variability of postoperative hearing preservation and how to maintain residual hearing with long-term listening experience.

#### Podium Paper I.F.

### **Normative Data on Audiovisual Speech Integration: Accuracy and Capacity Measures**

*Nicholas Altieri, PhD, Idaho State University, Pocatello, ID*

The ability to use visual speech cues and integrate them with the auditory signal is vital for listeners with mild to moderate hearing-impairment. It is therefore important to develop comprehensive methods for assessing integration skills and provide normative data on these measures. Ideally, comprehensive measures of multisensory integration should encompass accuracy scores obtained from open-set sentence recognition, in addition to assessments of processing speed. The latter is important because speech recognition is a process that unfolds in real-time. Integration measures examining processing speed have, for instance, included capacity, which compares multisensory processing speed to independent model predictions (Altieri & Townsend, 2011). (Capacity is calculated within the context of forced-choice detection tasks.) Recently, capacity measures have been developed which take into account reaction-times and accuracy (Altieri, Townsend, & Wenger, 2013). In this study, normative data on integration skills were obtained from a large group of listeners. They participated in open-set sentence recognition, and also a forced-choice speeded word recognition experiment. Raw scores were converted to T-scores to provide a standardized data set to which a listener with suspected hearing-impairment may be compared against. Finally, capacity showed a positive correlation with accuracy-based assessments reported from the sentence recognition study.

## **PODIUM SESSION II: COGNITION; TINNITUS**

#### Podium Paper II.A.

### **Mitigation of Age-related Changes in Cognition with Hearing Aids**

*Jamie Desjardins, PhD, University Of Texas At El Paso, El Paso, TX*

Hearing aid use is a proven intervention to alleviate some of the negative effects of Presbycusis. However, the impact of hearing aid use on cognitive function remains unclear. The effect of hearing aid use on cognitive abilities across sensory modalities and, the time course of auditory acclimatization-related changes on measures of cognitive function were examined in ten middle-aged adults who had never used hearing aids previously. Cognitive function was evaluated over well controlled baseline, treatment, and withdrawal study phases over a period of six months of 'real-world' hearing aid use. Study worn aids were

fitted to participants during the treatment phase. Working memory, selective attention, and processing speed abilities were assessed in auditory and visual sensory modalities nine times over 7 months. Significant treatment effects were evidenced at 2 weeks of hearing aid use on auditory measures of working memory and selective attention, and at 12 - 24 weeks of hearing aid use on a visual measure of working memory. This suggests hearing aid use can compensate for impairments at the level of the auditory system, and that over time, due to auditory acclimatization effects, hearing aid use may also improve processing mechanisms at the level of the central nervous system.

#### Podium Paper II.B.

##### **Auditory and Working Memory Training in Adults with Hearing Loss**

*Melanie Ferguson, PhD, Helen Henshaw, PhD, Dan Clark, NIHR Nottingham Hearing Biomedical Research Unit, Nottingham, UK*

*Dave Moore, PhD, Cincinnati Children's Hospital Medical Center, Cincinnati, OH*

Auditory training helps compensate for degradation in the auditory signal. For auditory training interventions to benefit people with hearing loss, any task-specific learning needs to generalize to functional benefits in their real-world listening. A series of three high quality training studies are discussed. A randomized controlled trial (RCT) of 44 adults with mild hearing loss showed generalized improvements in self-reported hearing and complex cognitive tasks that index executive functions. This suggests development of complex cognitive skills may be more important than the refinement of sensory processing. A study of 30 hearing aid users showed generalized improvements in a cognitively-demanding competing speech task and a dual-task of listening, with greatest improvements shown for challenging listening conditions. Outcome measures should be sensitive to the functional benefits of auditory training and be set at an appropriately challenging level. Finally, a double-blind RCT directly trained working memory in 62 hearing aid users. Results suggest that working memory trained in isolation offers no generalized benefits to real-world listening abilities. We propose combined auditory-cognitive training approaches, whereby training interventions develop cognition embedded within auditory tasks, are most likely to offer generalized benefits to the real-world listening abilities of people with hearing loss.

#### Podium Paper II.C.

##### **How Audibility and Hearing Loss Affect Emotional Experiences**

*Erin Picou, PhD; Todd Ricketts, PhD, Vanderbilt University Medical Center, Nashville, TN*

Emotional sounds can have a profound impact on how listeners with normal hearing think and feel. Pleasant sounds can influence stress recovery, cognition, and well-being, while unpleasant sounds can prepare a body and a mind for action, improving physical and cognitive performance. However, previous research suggests that listeners with hearing loss respond differently to emotional sounds than listeners with normal hearing. It is not clear if these changes are due to reduced audibility or to other auditory changes associated with hearing loss. The purpose of the present research was to quantify the effects of audibility on subjective ratings of emotional sounds for listeners with normal hearing and hearing loss. Both groups of listeners rated sounds on two dimensions: valence and arousal. Sounds were 1.5 s clips from a published corpus with normative data available (International Affective Digitized Sounds); sounds were presented at 4 signal levels (35, 50, 65, 80 dB SPL). Results suggest that ratings of arousal increase with signal level. Data from

both groups of listeners will be contrasted. The results of this study are expected to serve as a baseline for work intended to optimize hearing aid processing of emotional sounds.

#### Podium Paper II.D.

##### **Beta Oscillations and Working Memory Correlate in Adverse Listening Conditions**

*Ilse Wambacq, PhD; Gabriella Musacchia, PhD; Janet Koehnke, PhD; Joan Besing, PhD,*  
Montclair State University, Bloomfield, NJ

We evaluated the impact of two-talker babble on semantic processing using cortical EEG oscillations. Participants were eighteen monolingual young (20-35 years) adults with normal audiometric results bilaterally. The subjects listened in quiet and in two-talker babble to high predictability SPIN sentences that ended with a related final word, or an unrelated final word, spoken by a female speaker of standard American English. Sentences were presented at 0° azimuth. Two-talker babble was presented at +/- 90° azimuth. Subjects evaluated whether final words were related/unrelated to the sentence stem. Principal Component analyses were conducted for each stimulus type (related, unrelated) in quiet and in babble. Other variables entered were behavioral scores (RT and accuracy), cognitive test scores (Letter-number Sequencing  $\zeta$  LNS, Hopkins Verbal Learning Test, Boston Naming Test) and mean beta power in 100 ms bins between 0-700 ms. For Babble Related, LNS loaded on the same factor as early beta power (0-300 ms), showing that beta decreased more in individuals with better LNS scores than those with worse LNS scores. Beta decrease indicates engagement in unification (integrating words in a sentence); hence we conclude that better working memory and processing speed skills (LNS) are commensurate with early enhanced unification processes in babble.

#### Podium Paper II.E.

##### **Leisure Exposure to Music: Impact on Hearing and Tinnitus**

*David Moore, PhD; Resmi Gupta, MS,* Cincinnati Children's Hospital, Cincinnati, OH  
*William Whitmer, PhD; Michael Akeroyd, PhD,* MRC Institute of Hearing Research, Glasgow  
*Robert Mackinnon, PhD,* NIHR Nottingham Hearing Biomedical Research Unit, Nottingham  
*Oliver Zobay, PhD,* MRC Institute of Hearing Research, Nottingham

Current professional advice is to limit exposure to leisure music such as clubs, concerts and personal music players (PMPs). That advice is mainly based on assumptions about level of exposure and extrapolation from known effects of occupational noise exposure on audiometric, pure-tone sensitivity. A large, public participation experiment launched as part of the Medical Research Council's Centenary celebrations provided an opportunity to test the advice more objectively. Over 5000 adults (17-80y.o.) were recruited, mostly from media coverage in the UK. Participants logged in to a Centenary website where they answered questions about their hearing and exposure to leisure music, and completed a Digit Triplets Test. Trials of 3 spoken digits were presented adaptively against a low-pass noise (Vlaming et al., *Ear Hear.*, 2014). Speech reception threshold (SRT) worsened with age. There was no significant relationship between reported leisure noise exposure and SRT, or interaction with age. Separate analysis of clubs, concerts and PMPs produced similar results. Self-reported hearing difficulty increased with age and with duration of music exposure. Tinnitus reports were significantly higher in those who listened to leisure music, but the effect sizes were generally modest. We found no conclusive evidence that leisure noise exposure affected hearing.

### Podium Paper II.F.

#### **Test-Retest Reliability and Associations of Dichotic Listening Test Scores**

*Kairn Kelley, MS; Benjamin Littenberg, MD, University Of Vermont, Burlington, VT*

Dichotic tests, in which the right and left ears simultaneously receive different stimuli, are commonly used in batteries to diagnose auditory processing disorders. Their scores may be used to guide intervention and allocation of resources even though data about the reliability of the tests are limited, especially in children. Clinical guidelines for auditory processing assessment recommend comparing children's scores on different dichotic tests, but associations among scores within samples of children have rarely been reported. The author evaluated children's same-day test-retest performance on SCAN:3 Competing Words, Musiek's Double Dichotic Digits, and the Bergen Dichotic Listening Test with Consonant-Vowel Syllables (Non-Forced Attention). Sixty children, ages 7-14 with normal hearing, each made one visit during which the three tests were each administered twice. Group mean ear scores did not change between first and second administration of any of the tests. However, individual changes greater than 20 percentage points were observed on all three tests. When words and digits test scores were categorized as pass/fail, 8 children failed both tests both times, 32 children passed both tests both times, and 20 children failed some but not all. These data underscore the importance of considering within-subject variation when interpreting children's dichotic listening test scores.

### **PODIUM SESSION III: AMPLIFICATION; TECHNOLOGY**

#### Podium Paper III.A.

#### **Speech Understanding and Hearing Aid Technologies: Are Premium Features Better?**

*Jani Johnson, PhD; Jingjing Xu, PhD; Robyn Cox, PhD, University Of Memphis, Memphis, TN*

Hearing aid manufacturers offer hearing aids that function at varying levels of technological sophistication. The more advanced levels of digital signal processing are intended to improve outcomes in various listening environments. Advance in technology level corresponds to increase in cost to the end-user. However, independent research has not demonstrated that use of premium-level technology results in better everyday speech understanding outcomes than use of basic-level technology. Such evidence is needed to help end-users make cost-effective decisions when purchasing hearing aids. This research was designed to demonstrate the relative effectiveness of premium features compared with basic features in contemporary hearing aids in the outcome domain of speech understanding. Forty-five older adults with relatively symmetrical mild-to-moderate sensorineural hearing loss completed four blinded, one month field trials, using two pairs of basic-level, and two pairs of premium-level behind-the-ear hearing aids. Analyses of speech understanding performance tested in the laboratory under simulated real-world listening conditions, and responses to standardized questionnaires addressing daily life listening, demonstrated that speech understanding was improved with hearing aids compared to without hearing aids; however, no statistically significant differences in speech understanding benefit were observed between the premium and basic hearing aids. (Supported by NIDCD)

#### Podium Paper III.B.

#### **Hearing Aid Technology Effect on Front/Back Localization in Quiet**

*Jingjing Xu, PhD; Jani Johnson, PhD; Robyn Cox, PhD, School Of Communication Sciences And Disorders, University Of Memphis, Memphis, TN*

Compared to basic hearing aids, premium hearing aids have more advanced technologies and sophisticated features. With all superior functions taking action together, premium hearing aids are expected to yield better front/back localization performance than basic hearing aids. However, there is minimal evidence to support this belief. This research evaluated front/back localization performance in laboratory and real-world settings using basic and premium hearing aids. Forty-five older adults with mild-to-moderate hearing loss were bilaterally fitted with four pairs of BTEs (two basic and two premium) from two manufacturers. Laboratory and self-report outcomes were obtained for each pair after a four-week field trial. Laboratory tests were conducted in a sound-treated booth with a 360 degree, 24-loudspeaker array. Test stimuli were 1.3 second speech snippets that were high-frequency and low-frequency filtered, presented in quiet. Results showed that overall, premium hearing aids yielded significantly fewer errors than basic hearing aids with high-frequency sentences. However, there were no differences for low-frequency sentences. Further, there was evidence that one manufacturer's products yielded fewer errors than the other manufacturer. Despite some laboratory differences, self-report measures revealed no significant differences across hearing aids in daily life localization. (Supported by NIDCD)

*Podium Paper III.C.*

### **Comparison of Frequency Modulated (FM) and Wireless Accessory (WA) Remote Microphone Technology**

*Michelle Sanchez, BA; Kristi Oeding, AuD; Lisa Potts, PhD, Washington University In St. Louis School Of Medicine, Saint Louis, MO*

Remote microphones can supplement hearing aids to help reduce the signal degradation that occurs with a greater distance between a speaker and listener. This technology has been available via a frequency modulated (FM) system. Several hearing aid companies have recently released remote microphones that use technology similar to bluetooth. This new system involves a wireless accessory (WA) and a microphone that couples to the hearing aids. A randomized repeated measures single blind experimental design was used to evaluate 14 current hearing aid users' speech recognition while using the FM and WA systems. All participants were fitted with bilateral Phonak Bolero Q90 hearing aids, a WA system (Phonak ComPilot with RemoteMic), and a FM (Phonak Inspiro) system. Participants completed one testing session of speech in noise, tolerance of background noise, and a questionnaire regarding device preference. The WA provided greater benefit than the FM for speech recognition in noise. No statistically significant differences were seen in noise tolerance. Sound quality judgments showed that the majority of participants from this study preferred the FM over the WA. Due to the differences in objective and subjective findings, the evaluation of different technologies needs to include both objective and subjective measures.

*Podium Paper III.D.*

### **Evaluation of a BICROS with Directional Microphone on the Transmitter**

*Kristi Oeding, AuD; Michael Valente, PhD, Washington University In St. Louis - School Of Medicine, St. Louis, MO*

BICROS amplification has provided limited benefit in noise, despite the addition of a directional microphone (DM) on the receiver and an omnidirectional microphone (OM) on the transmitter. Recently, BICROS amplification was introduced with a DM on the receiver and transmitter, but no evidence is available on the efficacy and effectiveness of this advancement. The primary goal of this study was to determine differences in sentence recognition in noise between an OM and fixed DM on the transmitter with an adaptive DM on the receiver. Eighteen participants were fit with the BICROS and acclimatized for eight weeks. Participants used the OM or DM on the transmitter for four weeks, then switched to the OM or DM for the remaining four weeks. Participants were blinded to the conditions being evaluated. Three listening environments were examined with the transmitter utilizing an OM or a DM with HINT sentences in the R-Space: speech from 0° and noise from eight surrounding loudspeakers, speech to the transmitter and noise from 0°, 90°, and 180°, and speech to the receiver and noise from 0°, 90°, and 180°. Preliminary results revealed a mean 2.4 dB advantage for the DM compared to the OM in the diffuse listening environment.

### Podium Paper III.E.

#### **Binaural Directivity Patterns of Binaural Hearing and Implications on Hearing Prosthetic Design**

*Andrew Dittberner, PhD; Changxue Ma, PhD; Fredrik Gran, PhD, GN Resound, Glenview, IL*

It is accepted knowledge that having two ears are better than one when trying to listen to a signal of interest in the presence of spatially-separated noise sources (e.g. Blauert, 1997; Bregman, 1994; Zurek, 1993). Models have been proposed purporting of the benefits of the head shadow effect, binaural interactions, and cognitive factors that explain how one can understand sound with linguistic or other contextual meaning better in the presence of spatially-separate noise sources. However, less discussed is the attribute of human listeners having the ability to also hear and identify sound sources, seemingly on demand, that occur around them, a condition made possible by the fact of having two ears. Zurek (1993) proposed and discussed at length on the directivity effects of binaural listening (e.g. Better Ear Strategy). What is proposed in this study is an extension to this model to include the omni-directional directivity effects of binaural listening to describe the listener's ability to remain connected and aware of the sound landscape that surrounds them. Where the head shadow effect plays a role in improving the signal-to-noise ratio in one of the two ears, this strategy looks at how the two ears, due to their geometric location on the head, allows for the head to be acoustically transparent and keeps the listener connected to their surrounding sound landscape.

### Podium Paper III.F.

#### **Analysis of 2.4 GHz Antenna Performance in Terms of Speech Quality Using the RSSI Metric**

*Caslav Pavlovic, PhD; Meena Ramani; Nick Michael, Bat&Cat Inc.*

The Made for iPhone (MFI) hearing aid program has made it possible for the iPhone to deliver audio (phone calls and music) directly to compatible hearing aids without the use of a streamer accessory. The iPhone can also act as a remote microphone and stream the audio directly to hearing aids. More hearing aid and assistive listening device (ALD) manufacturers are joining the MFI program to satisfy consumer demand for streamlined audio connections with minimal number of accessories. The design of a robust wearable



2.4 GHz antenna is key to providing a good listening experience. In this paper we propose using a dB metric commonly employed in Bluetooth technologies, the Received Signal Strength Indicator (RSSI), which can be wirelessly read from the hearing aid. We map its relationship to speech quality by conducting listening experiments. When developing hearing aids, the RSSI can be used in real-world environments to evaluate the antenna performance instead of conducting laborious listening experiments. [Research supported by NIDCD of the NIH under Award Number R44DC014030. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.]

## **PODIUM PRESENTATIONS: Saturday, March 7, 2015**

### **PODIUM SESSION IV: PHYSIOLOGY; EVOKED POTENTIALS**

#### **Podium Paper IV.A.**

##### **Comparison of Otoacoustic Emissions Measured with Different Devices**

*Wiktor Jedrzejczak, PhD; Edyta Pilka, MS; Krzysztof Kochanek, PhD; Henryk Skarzynski, PhD, World Hearing Center, Institute Of Physiology And Pathology Of Hearing, Kajetany, Poland*

Otoacoustic emissions (OAEs) are characterized by high repeatability among consecutive measurements. On the other hand when patient is tested in different clinics it is likely that different devices would be used. The purpose of this study was to determine if there are differences in the parameters of OAEs recorded by different devices. Transiently evoked OAEs (TEOAEs) and distortion product OAEs (DPOAEs) were measured by five commercially available clinical devices. The default settings of the systems were used. The subjects were young people with normal hearing thresholds and normal tympanograms. Each subject was tested by all devices. Parameters of the signals such as response level and signal to noise ratio (SNR) were analyzed. Individual recordings as well as averaged over subjects data from all devices were compared. Significant differences between systems were found in parameters of TEOAEs and DPOAEs. Additionally the spectral patterns of responses was differed between recordings form different devices.

#### **Podium Paper IV.B.**

##### **ASSR Amplitude to Paired Stimuli that Covary in Modulation Depth**

*Robert Burkard, PhD; Kathleen Mcnerney, PhD, University At Buffalo, Buffalo, NY*

We have reported previously that the chinchilla auditory steady-state response (ASSR) is substantially decreased in amplitude when multiple stimuli are presented simultaneously. The present study evaluated the effects of covarying modulation depth of single and paired SAM stimuli on the amplitude of the ASSR. Carrier frequencies were 1000 and 2000 Hz, with modulation frequencies of 95 and 107 Hz, respectively. Stimulus level was fixed at 80 dB SPL. Each carrier frequency and depth of modulation (10% to 100%, in 10% increments) was presented to the right ear in isolation, and paired with the other stimulus (at the same modulation depth). The ASSR was recorded from subdermal scalp electrodes in eight adult isoflurane-anesthetized chinchillas, using the MASTER system. ASSR amplitude increased with increasing modulation depth, for both carrier frequencies. As in previous studies, the presentation of paired stimuli results in a decrease in ASSR amplitude

(for both components) across depth of modulation. The effects of modulation depth on ASSR amplitude when paired with a second stimulus will be compared to previously obtained amplitude interactions when one of the stimuli is fixed at 100% modulation depth, and the second stimulus is varied in modulation depth.

#### Podium Paper IV.C.

##### **Computational Auditory Model of Level Effects on Spectral Resolution**

*Evelyn Davies-Venn, PhD; Peggy Nelson, PhD, University Of Minnesota, Minneapolis, MN*

*Timothy Kwan; Muhammad Zilany, PhD, University Of Malaya, Malaysia*

*Yingjiu Nie, PhD, James Madison University, Harrisonburg, VA*

Physiological and behavioral measures have shown that as presentation level increases, frequency tuning broadens. However, results from our recent work suggest that the level-induced decrease in spectral resolution may differ for simple compared to complex spectral stimuli. This study used the Zilany et al. (2014) auditory nerve model with power law dynamics to assess stimulus and level-dependent changes in basilar membrane and auditory-nerve fiber responses. The main motivation was to examine the underlying mechanical and physiological processes that correlate with behavioral measures of presentation level effects on four different measures of spectral resolution. The measures were pure tone glide discrimination thresholds, notched-noise masked thresholds, spectral modulation detection threshold and spectral ripple discrimination thresholds. All thresholds were obtained on listeners with normal hearing and varying degrees of sensorineural hearing loss. Different sensation and sound pressure levels were selected to broadly elicit compressive and linearized basilar membrane responses for each listener. Results to date suggest differential effects of presentation level on thresholds for measures for measures using simple versus complex spectral stimuli. Level-dependent changes in specific components of basilar membrane and auditory nerve model responses correlate with changes in listeners' behavioral thresholds. The implications of these findings for amplification will be discussed.

#### Podium Paper IV.D.

##### **Extending Auditory Steady-State Response to Long-Latency Testing (ASSLLR): Threshold Estimation**

*Abreena Tlumak, PhD, Va Healthcare System, Pittsburgh, PA*

*John Durrant, PhD, University Of Pittsburgh, Pittsburgh, PA*

*Rafael Delgado, PhD, Intelligent Hearing Systems, Miami, FL*

A variety of 'objective' measures are available to estimate hearing sensitivity, yet perfect accuracy remains a challenge and interpretation is still often dependent upon examiner judgment and experience. Various efforts have been made to enhance traditional/transient auditory evoked potential (AEP) methods, but very little attention has been given to developing an analytical approach to objectify long-latency response (LLR) testing; that is, a steady-state stimulus response (SSR) approach to LLR measurement (ASSLLR). The LLR provides an unsurpassed combination of frequency specificity and accuracy of threshold estimates among AEPs. The authors have described the ASSLLR and efficacy findings in children and adults awake and in light sleep (Tlumak et al. IJA, 2011, 50:448-458; 2012, 51:418-423 & 480-490). Study aim: to evaluate efficacy of ASSLLR-based electric response audiometry (ERA). Repeated 1000-Hz tone bursts were delivered as sinusoidal pulse trains presented at 0.75 Hz repetition to produce a quasi-SSR. Responses for 20 normal-hearing

young adults were analyzed in both frequency and time domains to permit direct comparisons across methods. ASSLLR-estimated thresholds fell on average within 10 dB HL. Methods and caveats are discussed. Results are encouraging for overall efficacy of the SSR method for ERA, although clinical confirmation and other considerations warrant further investigation.

#### Podium Paper IV.E.

##### **Effects of Static Negative Middle-Ear Pressure on Wideband Acoustic Immittance**

*Sarah Robinson, MS; Jont Allen, PhD, University of Illinois At Urbana-Champaign, Urbana, IL  
Suzanne Thompson, PhD, St. John's University, Queens, NY*

Wideband acoustic immittance (WAI) measurements are capable of evaluating middle ear performance over a wide range of frequencies relevant to human hearing. It is known that static pressure in the middle ear cavity affects sound transmission to and from the cochlea, but few data sets exist to quantify this relationship. Eight subjects with normal middle ear function were trained to induce highly consistent negative middle ear pressures, quantified by the tympanic peak pressure (TPP), and the WAI was measured. The WAI near the tympanic membrane (TM-WAI) is estimated using a published method that accurately removes the residual ear canal contributions to the measurement, thus allowing for a direct comparison of the complex TM-WAI (magnitude and phase) for different subjects and probe insertion depths. For these subjects, negative TPP has the largest and most significant effect (a mean change of 2-3 [dB]) between 0.8-1.8 [kHz], causing less energy to be absorbed by the middle ear and cochlea. The TPP level was found to be a significant, but an imperfect predictor of TM-WAI change. Thus, it is important to consider the TM-WAI. Changes in the TM-WAI appear consistent with a stiffening of the annular ligament in the presence of middle ear pressure.

#### Podium Paper IV.F.

##### **Normative Study and Test-Retest Reliability of Wideband Tympanometry in Adults**

*Xiao-Ming Sun, PhD, Wichita State University, Wichita, KS*

Tympanometric measurements of wideband acoustic immittance have been investigated. This study aimed to present normative data of wideband tympanograms in adults from a research with subjects and procedural variables strictly controlled. Data were collected in 84 young adults. Energy absorbance (EA) was measured in response to clicks for frequencies from 0.236 to 8 kHz when the ear canal air pressure (ECP) was varied from +200 to -300 daPa. In 40 ears, seven consecutive trials and a trial of clinical 226-Hz Ya tympanometry were also run subsequently. Descriptive and inferential statistics were applied in analyses of the derived EA spectrum and the bandpass EA tympanogram to characterize variability and distribution of the sample and to estimate population parameters. Mean EA spectrums extracted from the wideband tympanogram were compared to EA measured with the ambient-pressure mode. Effects of ECP were also examined and the test-retest reliability of EA spectrums under various ECPs was assessed. The bandpass EA tympanogram, 0.236 and 1 kHz EA and Ya tympanograms, and 226-Hz tympanogram were collated in nine variables. Wideband tympanometry provides additional information concerning middle ear transfer function. It would enhance the application of wideband acoustic immittance in identifying conductive hearing loss and middle ear pathologies.

#### Podium Paper IV.G.

##### **Chirps Enhance Amplitude of Auditory Late Responses over Click Stimuli**

*Fred Holt, MS; Ozcan Ozdamar, PhD, Department Of Biomedical Engineering, University Of Miami, Coral Gables, FL*

Chirp evoked auditory evoked potentials (AEPs) have been shown to be capable of eliciting larger steady-state, brainstem and middle latency responses than traditional click stimuli. However, the chirp has not yet been evaluated as a viable stimulus for late AEPs (LAEPs), which have been difficult to study due to inter-subject variability and recording duration requirements. Recordings of LAEPs typically involve using population averages to compensate for low SNR. High fidelity broadband AEP recordings were acquired in 8 subjects using a 200us Click and a 10ms rising frequency chirp (200-8000 Hz). Stimuli were presented monaurally and diotically at a rate of 1 per second, at 50dB HL. Peaks (V, Na, Pa, Nb, P1, N1, P2, and N2) were identified for most individuals and conditions. Preliminary analysis suggests that chirp elicited AEPs result in higher SNR recordings and more prominent peaks for most AEP components compared to clicks. For the above peaks, a statistically significant increase in late response peak-to-peak amplitudes (54% to 113%) was observed. These results support the hypothesis that chirp stimuli may offer a clinical advantage over click stimuli in acquisition and assessment of Late AEPs, in addition to ABR, MLR and ASSRs.

#### Podium Paper IV.H.

##### **Signal-in-noise Electrophysiology and Behavior: Noise Type, Age, and Hearing Effects**

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Understanding speech in background noise is difficult for most listeners, and especially problematic for those with hearing impairment or age-related declines in auditory function. Even those with clinically normal-hearing thresholds demonstrate considerable variability in speech-perception performance in noise. The purpose of this study was to improve our understanding of how signals in noise are neurally coded and how these electrophysiological responses relate to perception-in-noise measures. Speech-in-noise stimuli were used with cortical auditory evoked potentials and coordinate response matrix behavioral testing to determine the effects of noise type (three noises were speech-spectrum continuous, one-talker modulated, and four-talker babble noise presented at various signal-to-noise ratios), and the effects of age/hearing impairment (10 young normal hearing, 10 older normal hearing, and 10 older hearing impaired individuals). Results revealed robust effects of noise type for both electrophysiology and behavior. However, group effects were strongest for behavioral testing and more subtle for electrophysiology. In addition, the relationship between electrophysiology and behavioral datasets will be determined and discussed in terms of the release from masking and informational masking literature. The combination of electrophysiological and behavioral data may lead to better diagnosis and rehabilitation of speech-perception-in-noise difficulties. [Supported by NIH/NIDCD (R03DC010914; R01DC011828) and VA/RR&D (C4844C)]

#### Podium Paper IV.I.

##### **Equivalency of Deconvolved Variable-Rate Swept-Tone SFOAE**

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Swept-tone (ST) stimuli are attractive in acquiring otoacoustic emissions (OAE) due to their increased frequency resolution. Stimulus-frequency (SF) OAE suffer from overlap of the elicited response with the stimulus, making OAE extraction difficult. If the response is deconvolved from the stimulus, then the resulting OAE resembles a transient-evoked (TE) OAE. In this study, we investigated the effect of sweep rate on the deconvolution of SFOAE using a ST stimulus with a 5 octave span (0.3 to 9.6 kHz). Linearly swept ST stimuli are typically reported in Hz/ms; however, our log-2 ST stimulus, which is required for nonlinear systems, is better expressed in octaves/sec. We examined rates of 100, 50, 25, 12, and 6 octaves/sec corresponding to stimulus durations of 50, 100, 200, 400, and 800 ms, respectively. We stimulated at a level of 55 dB-HL with the ST in addition to a conventionally acquired TEOAE at 55 pe dB-HL. We found that at all sweep rates the deconvolved SFOAE matched the TEOAE in temporal features and amplitude levels. ANOVA testing on correlation coefficient ( $p=0.98$ ), root mean square error ( $p=0.99$ ), and spectral coherence ( $p=0.97$ ) of deconvolved STOAE with TEOAE indicate no significant differences between sweep rates.

#### **PODIUM SESSION V: IMPLANTS; PEDIATRICS**

#### Podium Paper V.A.

##### **Perception of Musical Stimuli in MED-EL Cochlear Implant Users**

*Sandra Prentiss, PhD; David Friedland, MD; John Nash, MD; Christina Runge, PhD, Medical College Of Wisconsin, Milwaukee, WI*

Music perception remains one of the greatest challenges of electric hearing. The purpose of this study was to examine music perception performance with different acoustic and electric hearing configurations in MED-EL cochlear implant users. Music is a predominantly low-frequency auditory stimulus as compared to speech. The MED-EL device was tested due to the deep insertion and stimulation of low frequency regions. A same-different task was used for discrimination of two piano chord stimuli. Timbre perception was assessed using a 10-instrument forced-choice identification task. Fourteen cochlear implant users were tested representing 3 different listening configurations: unilateral cochlear implant (CI), bimodal (CIHA), and electro-acoustic stimulation (EAS). Fourteen normal hearing listeners served as controls. For the hearing impaired groups timbre perception was significantly harder than chord discrimination with respective mean scores of 55.3% and 78.3% ( $p=.004$ ). Conversely, normal hearing listeners showed significantly better performance on timbre perception than chord discrimination with respective mean scores of 98% and 90% ( $p=.005$ ). EAS users tended to perform better than both CI and CIHA groups possibly due to the return of full-spectrum perception of musical stimuli; acoustic low-frequency hearing and electric high-frequency hearing. Further analysis of timbre characteristics may contribute to advancements in programming strategies.

### Podium Paper V.B.

#### **18-Year Audiologic Follow-up of Children with Symptomatic Congenital Cytomegalovirus Infection**

*Winnie Chung, AuD; Tatiana Lanzieri, PhD; Stephanie Bialek, MD, Centers For Disease Control And Prevention, Atlanta, GA*

*Marily Flores, MS; Chantal Caviness, PhD; Gail Demmler-Harrison, Baylor College of Medicine, Houston, TX*

*Peggy Blum, AuD; Jerry Miller, Texas Childrens' Hospital, Houston, TX*

**Aim:** To describe the prevalence of sensorineural hearing loss (SNHL) in children with symptomatic congenital cytomegalovirus infection (ScCMV). **Methods:** Infants with laboratory diagnosis of CMV infection within 2-3 weeks of life and CMV-related symptomatology at birth (petechia/purpura, jaundice, hepatosplenomegaly or neurologic abnormalities) were followed-up annually on average. Audiologic evaluations included auditory brainstem response, behavioral audiometry, otoacoustic emissions and tympanometry. SNHL was categorized as auditory thresholds  $\geq 25$  dB, in the absence of middle ear disease. **Results:** Among 77 ScCMV infants, 45 (58%) were had congenital SNHL, 35 (78%) bilateral and 10 (22%) unilateral. Five (50%) children with congenital unilateral SNHL progressed to bilateral SNHL (median age at diagnosis: 3 years, range: 0.5-4 years). Twelve (38%) of 32 ScCMV infants without congenital SNHL were later diagnosed with SNHL (median age: 1 year, range: 0.5-10 years; 8 (25%) bilateral). By the last evaluation (median age: 12 years, range: 0.2-18 years), 57 (74%) ScCMV children had SNHL, 48 (84%) with bilateral losses. The number of ScCMV infants with permanent bilateral SNHL ( $\geq 40$  dB) increased from 30 (39%) at diagnosis to 42 (55%) at last evaluation. **Conclusion:** ScCMV children are at high risk of permanent bilateral SNHL, requiring ongoing audiologic follow-up and interventions.

### Podium Paper V.C.

#### **18-year Audiologic Follow-up of Children with Asymptomatic Congenital Cytomegalovirus Infection**

*Tatiana Lanzieri, MD; Winnie Chung, AuD; Stephanie Bialek, MD; Scott Grosse, PhD, Centers For Disease Control And Prevention, Atlanta, GA*

*Peggy Blum, AuD; Jerry Miller, Texas Children's Hospital, Houston, TX*

*Chantal Caviness, PhD; Gail Demmler-Harrison, Baylor College of Medicine, Houston, TX*

**Aim:** To describe the prevalence of sensorineural hearing loss (SNHL) in children with asymptomatic congenital cytomegalovirus infection (AcCMV). **Methods:** During 1982-1992, newborns identified through CMV screening (positive urine culture within 3 days of life) without CMV-related symptomatology were enrolled in the Houston Congenital CMV Longitudinal Study. Audiologic follow-up included auditory brainstem response (ABR), behavioral audiometry, otoacoustic emissions and tympanometry evaluations. SNHL was categorized as auditory thresholds  $\geq 25$  dB, in the absence of middle ear disease. **Results:** Among 92 AcCMV infants, 9 (10%) were diagnosed with congenital SHNL, 8 unilateral and 1 bilateral. During follow-up (biennial on average), 5 (63%) children with congenital unilateral SNHL were diagnosed with SNHL in the other ear (median age: 4 years, range: 0.5-9 years), and 11 (13%) of 83 AcCMV infants without congenital SNHL were later diagnosed with SNHL (median age: 9 years, range: 1-17 years; 3 (27%) bilateral). A total of 20 (22%) AcCMV children had SNHL, 9 (45%) with bilateral losses. Four (4%) AcCMV infants had bilateral SNHL  $\geq 40$  dB, and 8 (9%) had unilateral SNHL  $\geq 40$  dB. **Conclusion:**

The risk of newly diagnosed SNHL in AcCMV children persists into adolescence. Ongoing audiologic follow-up of AcCMV children is warranted.

#### Podium Paper V.D.

##### **Auditory Brainstem Implants for Children: Early Findings**

*Amy Martinez, MA; Laurie Eisenberg, PhD; Laurel Fisher, PhD, Keck School Of Medicine Of The University Of Southern California, Los Angeles, CA*

*Eric Wilkinson, MD, House Clinic and Huntington Medical Research Institutes, Los Angeles, CA*

*Margaret Winter, MS; Jamie Glater, AuD, Center for Childhood Communication/Keck School of Medicine of the University of Southern California*

Auditory brainstem implants (ABI) for young children is in the early stage of exploration in the United States under an FDA investigational device exemption and support from the National Institute on Deafness and Other Communication Disorders (NIDCD) to assess safety, feasibility, and early efficacy. The goal of this pediatric ABI clinical trial is to evaluate clinical safety in 10 children, ages 2 to 5 years, who are not candidates for, or demonstrate no benefit from cochlear implants due to cochlear nerve hypoplasia/absence or cochlear aplasia/severe malformation. Eligible candidates who meet inclusion criteria undergo audiological, medical, speech-language, cognitive, and radiological assessment, along with educational habilitation counseling. Surgical protocols have been developed and modified to document techniques that emphasize surgical safety and minimize later non-auditory side effects to ensure maximum number of useable electrodes for optimal auditory stimulation of the cochlear nucleus. To date, three children have undergone ABI surgery and device activation with no unexpected serious surgical adverse events. At 1- to 3-months post-activation, detection audiograms for pure-tones and speech range between 50 and 70 dB HL. IT-MAIS scores with the ABI range between 3 and 7 out of 40. Non-auditory side effects have been minimal. [NIH grant # U01 DC013031]

#### Podium Paper V.E.

##### **Binaural Benefit in Cochlear Implantees: Does Unilateral Spectral Resolution Matter?**

*Ward Drennan, PhD; Nancy Mcintosh, AuD; Jay Rubinstein, MD, University Of Washington, Department Of Otolaryngology, Seattle, WA*

*Elizabeth Anderson, PhD, Envoy Medical Corporation, St. Paul, MN*

Spectral ripple discrimination ability is well correlated with speech understanding in quiet and in noise for cochlear implantees (Won et al. 2007) and is, unlike speech perception, stable for one year postactivation (Drennan et al. 2011). For bilateral cochlear implantees, what happens if spectral discrimination varies between ears? It was hypothesized that the difference in spectral ripple discrimination ability between ears would be inversely related to binaural speech benefit. In preliminary work, eleven bilateral implantees were tested. Each ear was tested separately and both ears together using a spectral ripple discrimination test, AzBio sentences, consonant-nucleus-consonant (CNC) words in quiet, and the speech reception threshold (SRT) for spondees in steady noise. Mean binaural benefit was 8% for sentences, 3% for words, and 0.6 dB for the SRT. Preliminary results showed an inverse relationship between binaural benefit and between-ear difference in ripple scores for words ( $r = -0.57$ ) and SRT ( $r = -0.56$ ), suggesting that similar spectral discrimination ability between ears yields more binaural benefit. These preliminary results suggest the need for more extensive investigation leading to ways to optimize bilateral

mapping, and that the evaluation of unilateral spectral abilities might be useful for early prediction of binaural benefit for speech understanding.

#### Podium Paper V.F.

##### **Clinical Application of Spectral Envelope Perception: Year 1**

*Rene Gifford, PhD; Linsey Sunderhaus, AuD; Tim Davis, AuD; Adrian Taylor, AuD; Susan Amberg, Vanderbilt University, Nashville, TN*

*Michelle Blanchard, AuD, Tampa Bay Hearing And Balance, Tampa, FL*

*Jace Wolfe, PhD, Hearts for Hearing, Oklahoma City, OK*

*Tony Spahr, PhD, Advanced Bionics, Valencia, CA*

We will describe the findings of our multi-center, prospective, longitudinal study of new CI candidates to examine the clinical utility of a quick spectral modulation detection (QSMD) test for guiding CI ear selection and expectations management. At the time of abstract preparation, we had enrolled 228 adult CI candidates across the three study sites. Of the 228 patients, 162 received an implant in the first year of the project. Our preliminary findings suggest the following: 1) It is possible to integrate a clinically feasible test of spectral envelope perception into the clinical protocol for three busy implant programs, 2) adults are able to complete this task in both the pre- and postoperative periods (including activation), 3) as shown by others, there is no relationship between preoperative thresholds and postoperative speech recognition nor between pre- and postoperative speech recognition, 4) spectral envelope perception matures faster than speech recognition (as indicated earlier by Drennan et al., 2011), and 5) preoperative QSMD is correlated with postoperative word recognition in the CI only condition ( $r = 0.45$ ,  $p = 0.01$ ). Spectral envelope perception may be the first clinical measure of preoperative auditory function found to correlate with postoperative speech recognition outcomes.

#### Podium Paper V.G.

##### **The Effect of Hearing Loss on Early Word Processing**

*Susie Robertson, PhD, Hearing And Speech Foundation, Maryville, TN*

*Deborah Von Hapsburg, PhD, University Of Tennessee, Georgetown, TX*

*Jessica S. Hay, PhD, University of Tennessee, Knoxville, TN*

Children with hearing loss (CHL) face significant challenges during language acquisition due to limited access to speech. Although infant-directed-speech (IDS) is thought to play an important role in early language acquisition for children with normal hearing (CNH), relatively little is known about the benefits of IDS for CHL. We used a looking-while-listening paradigm to examine how CHL and CNH process familiar and novel words in IDS and adult-directed-speech (ADS). Eleven children with bilateral, sensorineural HL ( $M=32.48$  months) using hearing aids or cochlear implants, and 11 age-, gender-, and SES-matched NH controls participated. Performance in IDS and ADS was tested on different days. Vocabulary size was assessed using the MCDI. As expected, CNH had faster RT to look at familiar and novel target word objects than CHL. Further, CHL had higher accuracy in IDS than ADS for familiar words. Although CNH showed no accuracy differences, they displayed faster RT in ADS, perhaps reflecting their ability to take advantage of a faster speech-rate when processing familiar words. Vocabulary size of CHL was negatively correlated with RT to familiar words, suggesting that children with larger vocabularies processed familiar words more quickly. Data will be discussed in the context of current theoretical models.



Podium Paper V.H.

### **Dual-carrier Vocoder Processing: Cost of Preserving the Background**

*Frédéric Apoux, PhD; Eric W. Healy, PhD, The Ohio State University, Columbus, OH*

Dual-carrier (DC) vocoder processing is an encoding technique that allows the presentation of a target signal and the background simultaneously while significantly improving intelligibility (up to 60% points) when compared to traditional single-carrier (SC) vocoder processing. This technique may be especially suitable for cochlear implants (CIs). Thus far, the intelligibility improvement has only been established for one signal-to-noise ratio (SNR). The goal of the first experiment was therefore to demonstrate in CI simulation that a significant benefit of DC processing exists across a wide range of SNRs. While there are undeniable benefits of preserving the background, such as a more complex acoustic environment or the possibility for the CI user to mentally switch attention between sound sources, there is also a potential cost of preserving (i.e., encoding) the background. The goal of the second experiment was to assess this cost by comparing performance in DC conditions to a condition in which a single carrier was used but the background was suppressed. Overall, simulation data from these two experiments suggest that encoding the background is a viable strategy for CIs.

## **PODIUM SESSION VI: HEARING DISORDERS; EPIDEMIOLOGY**

Podium Paper VI.A.

### **Wind Turbines and Health: A Critical Review**

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*Robert Dobie, MD, University Of Texas, San Antonio, TX*

*Kenneth Mundt, PhD, Environ International, Amherst, MA*

*Kenneth Kaliski, Resource Systems Group, White River Junction, VT*

*Mark Blais, Massachusetts General Hospital, Boston, MA*

*David Colby, Middlesex-London Health Unit, London, Ontario, Canada*

We performed a systematic review of sound measurements near wind turbines (WTs), epidemiological and experimental studies of health effects of WT noise and infrasound, and factors associated with annoyance. We found that (1) infrasound levels near WTs do not exceed audibility thresholds; (2) epidemiological studies have shown associations between living near WTs and annoyance; (3) infrasound and low-frequency sound do not present unique health risks (in particular, there is no evidence that inaudible infrasound can be detected by, or cause harm to, experimental animals or humans); (4) annoyance seems more strongly related to individual characteristics than to noise levels from turbines. Preliminary results (Oct. 2014) from Health Canada's large prospective study confirm these findings. Further areas of inquiry include enhanced noise characterization, comparison of predicted noise levels to measured levels, longitudinal assessments of health pre- and post-installation, experimental studies in which subjects are blinded to the presence or absence of infrasound, experimental studies to determine whether infrasound can cause endolymphatic hydrops, clinical studies to determine whether people who complain of health effects from WTs have abnormal auditory or vestibular function or can be helped with tympanostomy tubes, and enhanced measurement techniques to evaluate annoyance.

## Podium Paper VI.B.

### **Antioxidant Vitamin Intake and Hearing Loss in Women**

*Sharon Curhan, MD*, Harvard Medical School, Brigham And Women's Hospital, Boston, MA

*Roland Eavey, MD*, Vanderbilt University Bill Wilkerson Center For Otolaryngology And Communication Sciences, Nashville, TN

*Konstantina Stankovic, MD*, Massachusetts Eye and Ear Infirmary, Boston, MA

*Gary Curhan, MD*, Harvard Medical School, Brigham and Women's Hospital, Harvard School of Public Health, Boston, MA

Background: Oxidative injury may contribute to hearing loss; therefore higher antioxidant vitamin intake may be protective. Methods: We examined independent associations between intake of carotenoids, Vitamins A, C, E, and folate, and self-reported hearing loss in 65,521 women (Nurses' Health Study II 1991 to 2009). Updated dietary information was obtained from validated questionnaires. Cox proportional hazards regression models were used to estimate multivariable-adjusted relative risks (RR). Results: 12,789 cases of incident hearing loss were identified. Compared with women with lowest beta-carotene intake, the multivariable-adjusted RR among women with highest intake was 0.87 (95% CI 0.78,0.98). Compared with women with lowest beta-cryptoxanthin intake, the RR among women with highest intake was 0.91 (95% CI 0.85,0.97). Higher folate intake tended to be associated with lower risk (p-trend 0.05). No significant associations were observed for other carotenoids, retinol, vitamin A, or vitamin E. Higher intake of vitamin C was associated with higher risk; compared with women with intake <90 mg/d, the multivariable-adjusted RR among women with vitamin C intake 1000+ mg/d was 1.15 (95% CI 1.02,1.30). Conclusion: Higher intakes of beta-carotene, beta-cryptoxanthin and possibly folate are associated with lower risk of hearing loss, while higher vitamin C intake is associated with higher risk.

## Podium Paper VI.C.

### **CHARGE Consortium Age-Related Hearing Loss Phenotypes for Genetic Epidemiology Studies**

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*Hannes Petersen, MD*, University of Iceland, Reykjavik, Iceland

*Lenore J. Launer, PhD*, NIA, NIH, Bethesda, MD

*Johanna Jakobsdottir, PhD; Gudny Eiriksdottir, MS; Vilundur Gudnason*, Icelandic Heart Association Research Institute and Clinic, Kopavogur, Iceland

No gold standard phenotype definition exists for Age-Related Hearing Loss (ARHL). The CHARGE (Cohorts for Heart and Aging Research in Genomic Epidemiology) Consortium facilitates genome-wide association (GWAS) study meta-analyses for well-phenotyped longitudinal cohort studies. In 2013, CHARGE established an ARHL Working Group, which proposed sex-specific phenotypes: 1) modified residual z-scores using better ear (BE) pure-tone average (PTA) of 0.5-1-2 kHz thresholds (R-PTA512); 2) modified residual z-scores using BE PTA 4-8 kHz thresholds (R-PTA48); 3) BE 'slope' differences between R-PTA512 and R-PTA48; 4) residuals after linear regression on age of BE PTA 0.5-1-2-4 kHz thresholds (R-PTA5124). We compared these phenotypes using the Age, Gene/Environment Susceptibility-Reykjavik Study (AGES-RS). Audiometry was conducted during 2002-2006 on 5,172 adults aged 66-96 years. AGES-RS participants were categorized into upper 20% (higher ARHL risk), middle 60%, and lower 20% by sex for

each phenotype. Agreement was substantial between R-PTA512 and R-PTA5124 (males, Kappa (K)=0.75, 95% confidence interval (CI):0.72-0.78; females, K=0.76, CI:0.74-0.78), but only moderate between R-PTA48 and R-PTA5124 (males, K=0.44, CI:0.40-0.47; females, K=0.42, CI:0.39-0.45). Using generalized linear regression models, significant ARHL risk factors for males and females were: tinnitus, ear infection history, occupational/leisure noise exposure, diabetes, and smoking; higher education reduced the risk.

#### Podium Paper VI.D.

##### **Epidemiology of Dizziness in Adolescence: The Add Health Longitudinal Study**

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*Anne E. Hogan Cline, PhD, School of Audiology, Pacific University, Hillsboro, OR*

*Bryan K. Ward, MD; Charley C. Della Santina, MD, Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD*

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The Add Health Study was Congressionally-mandated to examine adolescent health and risk behaviors in order to develop prevention strategies. It evolved into a longitudinal study tracking linkages from adolescence into young adulthood. Beginning with a nationally-representative sample of adolescents in school grades 7-12, selected in 1994-1995, interviews were conducted at schools initially and followed-up by four successive in-home interviews: Wave 1 (1994-1995; n=20,745), Wave 2 (1996; n=14,738), Wave 3 (2001-2002; n=15,197), and Wave 4 (2007-2008; n=15,701). In Waves 1-2, adolescents were asked about occurrence of dizziness in the past 12 months (never, just a few times, about once a week, almost every day, or every day). In Wave 2, the prevalence of dizziness - once a week or more frequently - was 6.5% (males, 5.3%; females, 7.7%). Using multivariable logistic regression, risk factors ordered by increasing magnitude were: fair/poor general health, odds ratio (OR)=2.0, 95% confidence interval (CI): 1.5-2.6; recent depression, OR=2.5, CI: 1.9-2.6; poor appetite, past year-almost every day (PY-AED), OR=3.0, CI: 2.0-4.6; aches/pains or sore muscles/joints PY-AED, OR=3.2, CI: 2.2-4.6; headaches PY-AED, OR=3.5, CI: 2.6-4.6. Dizziness reported in Wave 2 was significantly associated with self-reported hearing trouble and tinnitus in Waves 3-4.

#### Podium Paper VI.E.

##### **TT-Electrocochleography Obtained at High Stimulus Rates in Patients with Meniere Disease**

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*Jorge Bohorquez, PhD; Rafael Delgado, PhD, Biomedical Engineering, College of Engineering, University of Miami, Coral Gable, FL*

Objectives: To investigate a new strategy of auditory evoked responses recorded at high stimulation rates in Meniere disease ears (MDEs). Methods and Measures: Control ears (CEs) and 32 MDEs were tested using an evaluation strategy of the auditory system involving a Continuous Loop Averaging Deconvolution technique (CLAD) (Delgado & Ozdamar, JASA 2004; Ozdamar & Bohorquez, JASA 2006). Hearing was tested by transtympanal electrocochleography (TT-ECochG). Ears were stimulated using clicks (85

dB nHL) presented at rates of 7/s-780/s with the CLAD option. Results: In the CEs, the SP/AP ratio reached  $\approx 1$  at a stimulation rate of 600/s while in MDEs at 50-100/s. AP latencies in the CEs were found to be increasing at stimulation rates equal to 300/s, then were stable, and for rates of  $\geq 500$ /s, were found to be decreasing. For MDEs, latency changes were relatively similar to stimulation rate 250/s, and then, the latency remained stable. AP amplitude reduction pattern in MDEs was also different comparing to CEs. Conclusions: These very high stimulation rates provide a valuable tool for the assessment of the adaptation processes of the peripheral auditory system in CEs and MDEs. The CLAD strategy supports traditional audiological test battery in diagnosis of typical cochlear auditory pathologies.

#### Podium Paper VI.F.

### **Community-based Participatory Research on Hearing Loss in a Border/Low-Resource Community**

*Nicole Marrone, PhD; Maia Ingram, Mph; Jill De Zapien; Daisey Sanchez; Frances P. Harris, PhD; Stephanie L. Adamovich, PhD; Sonia Colina, PhD; Scott Carvajal, University Of Arizona, Tucson, AZ*

Many more people are in need of hearing healthcare than are currently being served in the US. It is therefore essential that researchers collaborate with community members and providers to assess the state of care and develop interventions to expand access. The community health worker (CHW) model has been used successfully in U.S.-Mexico border communities to increase access to healthcare and self-management of chronic health conditions. Here we describe a community-based participatory research (CBPR) process used in planning a hearing health and wellness program for a traditionally underserved patient population using a CHW approach. An academic-community partnership was formed with a rural federally-qualified health center serving low socio-economic status Mexican American adults. Partners engaged in a theory-based needs assessment of hearing loss among the population in Nogales, Arizona using the social-ecological and health belief models. The resulting multicomponent intervention, ¡Oyendo Bien!, aims to reduce disparities in access to hearing healthcare and improve outcomes identified as important to families experiencing hearing loss. The use of CBPR methods provided a way to identify barriers and facilitators in access to care and raise the profile of hearing loss as an important health issue in the community. [Research supported by NIH/NIDCD.]

#### Podium Paper VI.G.

### **Patients with Misophonia: An Introduction**

*Michael J. A. Robb, MD, Robb Oto-neurology Clinic, Phoenix, AZ*

Children and adult patients present to the oto-neurology clinic with complaints of specific sound intolerance. Annoyance and negative emotions are triggered by very soft sounds. Common examples include oral and salivary sounds, chewing, lip smacking, throat clearing, repetitive clicking, and even sights, such as an object or a person capable of making the offensive soft sound. Patients experience an abnormal heightened sense of rage, anger, anxiety, internal stress and tension, fight or flight and have the extreme desire to make the person stop producing the offending noise at once. This case series of five patients is presented with the goal of raising awareness about misophonia, the misphonic patient and family, and the common, uncommon and bizarre clinical scenarios. These patients have neither hearing loss nor hyperacusis. Each patient's personal and family history, specific

sound triggers and treatment strategies are highlighted. Included is a brief review of the emerging misophonic literature. Recognizing and diagnosing misophonia promptly while validating the patient, avoiding unnecessary interventions, counseling the patient, modifying behavior, and using sound therapy in a practical manner is wise care until more is known about the misophonic patient, the etiopathophysiology, genetics, and the clinical course of this benign but potentially disabling condition.

#### Podium Paper VI.H.

### **Inpatient and Outpatient Costs of Hearing Loss in the US Military: Preliminary Findings**

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*David Tucker; Tanisha Hammill, MS; Mark Packer, MD, Department Of Defense Hearing Center Of Excellence, Lackland AFB, TX*

*Natasha Gorrell, MS, The Geneva Foundation, Tacoma, WA*

*Andrew Senchak, MD, Walter Reed National Military Medical Center, Bethesda, MA*

**Objectives:** The goal is to comprehensively determine the economic impact of hearing injury among active duty US service members (SM). A significant cost category associated with hearing loss is direct medical costs, which include inpatient and outpatient costs. **Methods:** The population studied is active duty military SM during the January 1 2007 to Dec 31, 2012 timeframe. This research reports preliminary findings from two M2/MDR clinical data sets: Standard Inpatient Data Record (SIDR) and Comprehensive Ambulatory Provider Encounter Record (CAPER). **Results:** For 2007 to 2012, we obtained 11,122,965 encounter records from CAPER, representing 2,791,566 distinct patients and 27,185 encounters from SIDR, representing 21,239 persons. For outpatient direct care data, using Relative Value Units (RVUs) for clinical encounters, estimates of cost can be calculated using conversion factors appropriate for the year and location of the encounter. For inpatient direct care, estimates in dollars are provided in the clinical encounter record. To determine costs, an initial effort will use RVU values of CPT codes in encounter records having diagnoses based on the case definition. **Conclusions:** Cost estimates could identify high-burden groups, enable proactive measures for concerted education and training, identify best practices, and develop return-to-duty programs following hearing loss.