

**American Auditory Society Scientific and Technology Meeting  
March 7-9, 2013**

**PODIUM PRESENTATIONS:** Thursday, March 7, 2013

**PODIUM SESSION I: SPEECH PERCEPTION; AMPLIFICATION**

Podium Paper I.A.

**Speech Perception and Bayesian Modeling**

*Arthur Boothroyd, PhD, San Diego, CA*

Perception requires deciding the most likely origin of sensory evidence as rapidly and accurately as possible. In speech perception, the origin can include movements, sounds, phoneme categories, words, sentences, and meaning. In addition to sensory evidence, the perceiver receives contextual evidence. He or she brings both knowledge and skill to bear on the task of deciding probable origins. In speech perception, the knowledge is cognitive, social-cognitive, and linguistic. It is the source of all possible origins. The perceiver also knows the relative probabilities of the possible origins being the actual origin - before the evidence was received. Processing skill requires a reevaluation of these probabilities after the evidence is received. Thomas Bayes provided both a descriptive and a quantitative model of this process. In simulation, the application of Bayes' model predicts such phenomena as categorical perception, priming, and the McGurk effect - as demonstrated in this presentation. This model carries implications for both the consequences of hearing loss and their remediation.

Podium Paper I.B.

**SNR Loss Revisited: Individual Differences in the Slope of the Intelligibility Function**

*Ken Grant, PhD; Sandeep Phatak, PhD, Walter Reed National Military Medical Center, Bethesda, MD*

Clinical tests of the ability to understand speech in noise (e.g., Quick SIN) measure word or sentence recognition at different speech-to-noise ratios (SNR) and compare the 50% performance level (SNR50) to that of a group of normal hearing listeners. The result, or SNR loss, shows that hearing-impaired listeners typically require more favorable SNRs than normal-hearing listeners to achieve the same level of performance. This single point of comparison, however, leaves out an important aspect of one's ability to hear in noise, namely the slope of the intelligibility function. This slope describes the improvement in speech recognition for each dB improvement in SNR. Listeners with shallow slopes are expected to derive less benefit from directional microphones and noise-reduction algorithms than listeners with steeper slopes. In this study, the slopes of performance functions using nonsense syllable phrases were measured. Syllable recognition was tracked to 30% and 70% correct levels. Additionally,

subjective estimates of 0% and 100% syllable recognition were also obtained. The resulting data were used to estimate slopes around the 50% recognition point. Preliminary results suggest that performance slopes and traditional SNR loss measures reflect distinct aspects of hearing and may be useful in characterizing problems encountered in noisy environments.

Podium Paper I.C.

### **Advantages of Using Amplification for Early Age-Related Hearing Loss**

*Karen Doherty, PhD; Jamie Desjardins, PhD, Syracuse University, Syracuse, NY*

Age related hearing loss occurs very gradually and is often overlooked in its earlier stages. Untreated hearing loss has been linked to depression, withdrawal from social situations, impaired memory, and reduced job performance (NCOA, 1999). However, many people wait years before seeking treatment for their hearing loss. The purpose of the present study was to determine if hearing aids can be used to minimize the cognitive and social consequences of an age-related hearing loss in its earlier stages. Participants in this study ranged in age from 46 - 72 years and had never worn hearing aids or sought help for their hearing loss. Receiver in the canal hearing aids were fit bilaterally on all participants. They were asked to wear the hearing aids every day for six weeks. During this six week period, experimental testing was performed over five sessions. Results indicated that participants' working memory, both in quiet and noise, was significantly improved while wearing hearing aids. At the end of the six weeks, participants' hearing handicap was significantly reduced and their attitudes towards hearing aids changed.

Podium Paper I.D.

### **Within-Consonant Perceptual Differences in the Hearing Impaired Ear**

*Andrea Trevino, MS; Jont Allen, PhD, University Of Illinois Urbana Champaign, Urbana, IL*

A significant impediment to the development of diagnostic speech tests for hearing impairment is the large amount of natural variability in speech. Multiple tokens of the same consonant are often considered as multiple measures of the same effect. We analyze the responses of 17 ears with sensorineural hearing loss (SNHL) to consonant-vowel stimuli, composed of 14 American English consonants followed by the vowel /a/, and presented in varying amounts of speech-shaped noise. The analysis focuses on within-consonant perceptual differences (i.e., individual differences over tokens of the same consonant). Within-consonant perceptual differences are observed in both the robustness to noise and/or the resulting confusion groups. The differences in noise-robustness are shown to be correlated to the noise-robustness of the tokens for normal-hearing listeners. When the SNHL ears make an error, they all tend to draw from the same limited, token-dependent confusion group. These consistencies, observed across SNHL ears, imply that the acoustic properties of each token define the possible confusions. Although the tested tokens are noise-robust and unambiguous for normal-hearing listeners, the subtle natural variations in signal properties can lead to these systematic differences for SNHL ears.

Podium Paper I.E.

## **Effects of Speech Recognition Test on Cognition/Release Time Relationship**

*Jingjing Xu, PhD; Robyn Cox, PhD, University of Memphis, Memphis, TN*

Researchers hope to use hearing aid (HA) users' cognitive abilities to predict release time (RT) prescription. Previous studies have been contradictory regarding the cognition/RT relationship. Linguistic context of speech recognition tests was suspected as one factor that accounted for the inconsistency. The goal of this study was to examine the relationship between cognitive abilities and aided speech recognition performance with short and long RTs using test materials with different linguistic context. Thirty-four experienced HA users with mild-to-moderate hearing loss were recruited. Their cognitive abilities were quantified using a reading span test. Digital behind-the-ear style HAs with adjustable RT were fitted bilaterally. Their aided speech recognition performance was evaluated using three tests with different linguistic context. Results showed that (1) compared to those with low cognitive abilities, HA users with high cognitive abilities performed better on the two tests with more linguistic context when using short RT; (2) none of the three tests produced significantly different performance between short and long RTs for either cognitive group. The finding did not support the hypothesis of the effect of linguistic context on aided speech recognition performance with different RTs. The results further suggested that cognitive ability might not be important in prescribing RT.

Podium Paper I.F.

## **Frequency Compression Hearing Aids: Impact on Speech and Language Development**

*Ruth Bentler, PhD; Elizabeth Walker, PhD, University of Iowa, Iowa City, IA*

*Ryan McCreery, PhD, Omaha, Nebraska*

*Rick Arenas, PhD; Patricia Roush, AuD, UNC School of Medicine, Chapel Hill, NC*

Signal-processing options such as nonlinear frequency compression (NLFC) have been introduced to expand the potential for communication success for adults and children with hearing loss. Due to the limited bandwidth of current transducers, development of a strategy that provides access to frequencies above 6000 Hz has been encouraged by previous research (e.g., Stelmachowicz et al., 2001 & 2007). As a result, this and similar processing schemes are now the default in many hearing aids. In this study, we assessed speech and language outcomes for a subset of children who are participating in a large multi-site observational study of outcomes with children with hearing loss (OCHL; NIH RO1 DC009560). Subjects at ages 3, 4, and 5 years comprised the data pool; half of the subjects were fitted with NLFC and half were fit with more conventional signal processing schemes. None of the demographic variables between the groups, including age of diagnosis, age of fit, daily use time, SES, etc., were significantly different. Results indicated no differences in speech and language outcomes for the two groups at any of the three age levels. Further research is needed to determine the likelihood of improving these critical areas of development with alternative fitting and processing schemes.

## PODIUM SESSION II: COCHLEAR IMPLANTS; BIMODAL HEARING

Podium Paper II.A.

### **Performance for Severe to Profoundly Deaf Adults and Adolescents with a Hybrid Cochlear Implant**

*Camille Dunn, PhD; Marlan Hansen, MD; Bruce Gantz, MD, University of Iowa, Iowa City, IA*

The Nucleus Hybrid cochlear implant system allows individuals with hearing losses in the high-frequency region an alternative to traditional cochlear implantation. Because of their shorter length, the hybrid device stimulates the more basal end of the cochlea resulting in hearing preservation. The purpose of this study is to determine if individuals with preserved residual low-frequency hearing can develop improved speech perception by combining their acoustic hearing with electrical processing. Adults and children (ages 5-15 years) with sensorineural hearing loss with a pure-tone average (PTA) between 60-90 dB HL (70-90 dB HL in children) between 125-1500 Hz are being studied. These criteria are different than the current Cochlear Americas sponsored Hybrid multi-center trials as adults in those studies must have a threshold at 500 Hz at or better than 60 dB HL. Preliminary results describe preservation of residual hearing in both populations. In addition, speech perception data in quiet and in noise show better performance in the combined versus electric alone condition demonstrating integration of low-frequency acoustic hearing with high-frequency electrical stimulation. These findings show benefits of preservation of low-frequency acoustic hearing through better signal to noise ratios for speech perception in noise and improved localization of sound.

Podium Paper II.B.

### **Multisensory Integration in Adult Cochlear Implant Users with Hearing Preservation**

*Rene Gifford, PhD; Ryan Stevenson, PhD; Juliane Kruger, MS; Sterling Sheffield, AuD; Mark Wallace, PhD, Vanderbilt University, Nashville, TN*

Research has shown that hearing preservation in the implanted ear yields significant benefit for speech recognition in complex environments (e.g., Dunn et al., 2010; Gifford et al., in press). While significant, the effect size is relatively small, ranging from 10- to 12-percentage points. Patient reports, however, are overwhelmingly positive regarding improved ease of listening and communication. Thus the purpose of this study was to evaluate whether preserved hearing in the implanted ear yielded greater audiovisual integration than the bimodal condition. Utilizing a within-subjects, repeated-measures design, audiovisual integration was assessed for six adult participants. Tasks included the McGurk effect and simultaneity judgments (SJ) for audiovisual stimuli (onset asynchronies +/-500 ms). For the McGurk effect, participants exhibited greater audiovisual integration in the best-aided condition (20% increase,  $p=0.09$ ), providing empirical support of patients' subjective reports. For the SJ task, however, the width of the temporal binding window (TBW) - typically inversely proportional to the strength of integration - was

consistently wider for the best-aided condition. Binaural summation associated with the best-aided condition may have affected perceived loudness for the low-frequency tone. Greater loudness perception influences perceived tonal duration, having the potential to confound the SJ results. Future research is warranted to explore this unexpected result.

#### Podium Paper II.C.

### **Auditory and Visual Adaptation in Cochlear Implant Speech Perception**

*Matthew Winn, PhD, University of Wisconsin-Madison, Madison, WI*

*Ariane Rhone, PhD, University of Iowa, Iowa City, WI*

*Monita Chatterjee, PhD, Omaha, NE*

*William Idsardi, PhD, College Park, MD*

Successful perception of speech involves the adjustment to the naturally-occurring acoustic and visual differences between different talkers. In this study, we demonstrate that listeners with cochlear implants (CIs) accommodate variability on multiple levels while perceiving consonants. Listeners identified fricative sounds along a /s/-/S/ continuum in CV words in the context of rounded/unrounded lips during the vowel and/or consonant, female/male voices, and female/male faces; all of these contexts were orthogonally crossed. Consonant perception was modeled using mixed-effects logistic regression to quantify the effect of the various contexts on perception of the consonants.

CI listeners (but not normal-hearing listeners) used visual cues to gender to influence consonant perception in a way that was consistent with the acoustic differences between female and male voices. Furthermore, CI listeners' use of visual lip-rounding cues was consistent with perception of the entire syllable rather than just the individual segments.

These results suggest that listeners with CIs can 1) demonstrate sensitivity to spectral contexts, 2) exploit relationships between visual characteristics of talkers and acoustic properties of those talkers' voices. Thus, rehabilitation strategies may stand to benefit from reinforcing the association between auditory and visual cues as well as the incorporation of various contexts in training.

#### Podium Paper II.D.

### **On the Potential Use of Non-Linguistic Measures to Evaluate Cochlear Implant Candidacy**

*Ward R. Drennan, PhD; Elizabeth S. Anderson, PhD; Hyun Joon Shim, MD; Jong Ho Won, PhD; Il Joon Moon; Jay Rubinstein, MD, University of Washington, Seattle, WA*

The primary audiological criterion for cochlear implant (CI) candidacy is best aided sentence recognition of less than 50%. This requirement involves significant test time and clinical resources to ensure a 'best-fit' aided condition. This protocol can also be problematic for patients who speak languages for which there are no available speech testing materials. This study explores the possibility of using surrogate non-linguistic measures without amplification. Nine potential cochlear implant candidates (16 ears) with severe-to-profound hearing loss were tested. Spectral-ripple discrimination ability and temporal modulation detection thresholds

were evaluated with stimuli presented via insert earphones at comfortable loudness levels. Strong correlations were obtained between spectral-ripple thresholds and both aided sentence recognition ( $R^2=0.56$ ,  $p < 0.0005$ ) and unaided word recognition ( $R^2=0.58$ ,  $p < 0.0004$ ), but no significant relationship was found between temporal modulation detection threshold (TMDT) and either aided sentence or unaided word recognition. Spectral ripple discrimination thresholds were predictive of speech recognition performance. The unaided spectral'ripple discrimination test could enable a more efficient process for evaluating cochlear implant candidacy. The test could also be potentially useful when speech test materials are not available in the patient's native language. [This work was supported by NIH grants R01-DC010148, P30-DC004661.]

Podium Paper II.E.

### **Speech Perception Abilities of Older and Younger Adults with Cochlear Implants**

*Doug Sladen, PhD, Mayo Clinic, Rochester, MN*

*Rajka Smiljanic, PhD, University of Texas, Austin, TX*

Rationale: Age related declines in speech understanding, especially in noise, have been found among adults with normal or close to normal hearing, but less so among adults with CIs. This study hypothesizes that age related difficulties understanding speech in noise are not avoided with a cochlear implant. The purpose of this study is to examine auditory aging among older and younger CI listeners using a variety of materials presented in quiet and noisy conditions. Methods: A total of 15 older and 15 younger CI adult participants in this study were tested using single words in quiet single words in quiet, sentences in noise, sentences with high and low predictability spoken with rapid conventional style as well as with a slow clear speaking style. Results: Results demonstrate that older CI adults achieve the same high levels of performance in favorable listening conditions, but significantly worse in noise. Performance trends on high and low context sentences spoken in conversational or clear speech style will be explored. Conclusions: Older CI adults achieve less benefit understanding speech in noise than younger CI adults, supporting existing reports that age related declines in speech understanding are multifactorial and not constrained to peripheral deficits.

Podium Paper II.F.

### **Listening in a Cocktail Party with Cochlear Implants**

*Louise Loisel, MS; Michael Dorman, PhD; William Yost, PhD; Sarah Cook, Arizona State University, Tempe, AZ*

*Renee Gifford, PhD, Vanderbilt University, Nashville, TN*

Patients with bilateral CIs and patients with a single CI and bilateral, low-frequency acoustic hearing (hearing preservation patients) were tested in an environment that allowed computation of spatial release from masking and the binaural advantage. The environment was a simulated "cocktail party" with informational maskers and targets spatially separated. The bilateral CI patients showed a small, but significant, spatial release and a binaural

advantage (summation plus squelch). The hearing preservation patients showed only a binaural advantage. Access to interaural time difference (ITD) cues appears not to be necessary for minimal spatial release from masking.

### **PODIUM SESSION III: MIDDLE EAR; EVOKED POTENTIALS; DISORDERS**

Podium Paper III.A.

#### **Conventional and Multi-Frequency Tympanometric Norms for Caucasian and Chinese School-Aged Children**

*Navid Shahnaz, PhD, University of British Columbia, Vancouver, BC, Canada*

*Vahideh Bosaghzadeh, MS, Markham, Ontario, Canada*

The goals of this study were 1) to establish normative tympanometric data for school-aged children using conventional and multifrequency tympanometry; 2) to determine whether the results vary significantly between Caucasian and Chinese children, male and female children, and children and adults; and 3) to compare normal paediatric tympanometric data with tympanometric data obtained from children with middle-ear pathology. The control group consisted of 98 participants. There were 55 participants in the Caucasian control group, and 43 participants in the Chinese control group with an average age of 5.8 years. Those with confirmed middle-ear effusion (21 subjects) were recruited through the British Columbia Children's Hospital otolaryngology department using myringotomy and video otomicroscopy. Chinese school-aged children had lower  $V_{ea}$  and  $Y_{tm}$ , wider TW, and higher RF values than did Caucasian school-aged children. Diseased group tympanometric data was significantly different from normal group data. The effect of age was significant for all tympanometric variables. Test performance on tympanometric variables was objectively evaluated using receiver operating characteristic (ROC) curve analyses at each probe-tone frequency (226-, 678-, and 1000-Hz). Statistical comparison of the area under ROC (AUROC) plots revealed that  $Y_{tm}$  at 678-Hz had better test performance in distinguishing normal middle-ear status from MEE than did  $Y_{tm}$  at other probe-tone frequencies (226-, and 1000-Hz). Among all tympanometric parameters, the results showed that  $Y_{tm}$  from a 678-Hz probe-tone frequency, TW, and RF had the highest sensitivity, highest specificity, and statistically higher test performance in identification of MEE in school-aged children, across both ethnicities.

Podium Paper III.B.

#### **Reliable Differences in Wideband Otoreflectance Patterns Among Adults**

*Greg Flamme, PhD; Kristy Deiters, AuD; Amanda Tatro; Kyle Geda; Kara McGregor, Western Michigan University, Kalamazoo, MI*

Significance. Noise-induced hearing loss (NIHL) magnitudes are not perfectly correlated to the amount of noise in the listener's environment. Susceptibility is the difference between the observed and expected NIHL. Intersubject differences in energy transfer through the middle

ear could contribute to susceptibility, but only if those differences are reliable and substantial. Wideband reflectance (WBR) measurements can expose such differences.

**Method.** Reflectance measurements were obtained on adults (210 women; 169 men) without signs or symptoms of active middle ear disorders. Data were obtained using the Interacoustics WBR/WBT system. Observations were made twice per day over a total of 5 visits, with no more than 14 days separating measurements.

**Results.** The mean WBR function followed the shape of the A-weighting filter function, but individual values covered a broad range. Intraclass correlations were high ( $\sim 0.90$ ) at 3 and 4 kHz and moderate ( $> 0.60$ ) above 0.5 kHz. Thirteen typical shapes were identified. Shapes were related to demographic, physical, and procedural factors.

**Conclusions.** Reliable patterns of middle ear energy transfer were observed among adults with no signs or symptoms of middle ear disorders, and it is plausible that these differences could relate to NIHL susceptibility.

Podium Paper III.C.

### **Interaction of Multiple ASSR Stimuli that Vary in Level**

*Robert Burkard, PhD; Kathleen McNerney, State University of New York, Buffalo, NY*

We have previously reported substantial amplitude reductions of the chinchilla auditory steady-state response (ASSR) when two or more stimuli are presented simultaneously. In order to optimize recording efficiency, it may prove efficacious to use different carrier levels when using multiple carriers simultaneously. The present study evaluated the effects of varying carrier level on the amplitude of the ASSR to paired stimuli. Carrier frequencies were 1000 and 2000 Hz, with modulation frequencies of 95 and 107 Hz, respectively. Stimulus level was 60, 70 and 80 dB SPL. Each carrier frequency was presented to the right ear in isolation, and each level of one carrier frequency was paired with multiple levels of the other carrier frequency. The ASSR was recorded from subdermal scalp electrodes in nine adult isoflurane-anesthetized chinchillas, using the MASTER system, and varying the level of each component with TDT attenuators. ASSR amplitude increased with increasing stimulus level. As in previous studies, the presentation of paired stimuli results in a decrease in ASSR amplitude (for both components), and was greater for the lower carrier frequency. This amplitude decrement is greater for higher stimulus levels, and is affected by the relative level of the two carrier frequencies.

Podium Paper III.D.

### **Reliability of 80Hz Click ABRs-ASSRs with Simultaneous Contralateral Click Stimulation**

*Magdalena Lachowska, Medical University of Warsaw, Poland*

*Jorge Bohorquez, PhD; Ozcan Ozdamar, PhD, University of Miami, Coral Gables, FL*

This study evaluated the reliability of 80Hz auditory evoked potentials elicited by one ear when contralateral ear was simultaneously stimulated by an independent sequence of clicks with different intensity. We assessed the reliability of both the transient and steady-state responses



as function of contralateral stimulus level. Seven normal hearing adult subjects were stimulated with two periodic, low jitter and low cross-talk sequences with mean rates of 78.125Hz and 78.7402Hz for right and left ears, respectively. The right ear intensity was kept at 30 dBnHL while left ear level was varied from 0 dBnHL through 60 dBnHL in 10dB steps. Two channels of EEG (Cz/A2 and Cz/A1 forehead-ground) were amplified, filtered and sampled (100K, 30Hz-1500Hz and 10KHz). The transient ABR/MLRs and ASSRs were obtained by using synchronous averaging followed by deconvolution (Continuous Loop Averaging Deconvolution, CLAD). Regardless of the contralateral stimulus intensity, the test ear stimulus produced stable, identifiable ABR/MLRs and ASSRs. The latency and amplitude of peak V were  $8.73 \pm 0.05$  ms and  $0.34 \pm 0.03$   $\mu$ Vpp, respectively. The ASSR amplitude was  $0.24 \pm 0.01$   $\mu$ Vpp. The results show that contralateral stimulation doesn't produce appreciable changes in the evoked response that could lead to false detection in hearing screening applications.

Podium Paper III.E.

### **Training Effects in Older Adults: Neural Mechanisms**

*Samira Anderson, PhD*, University of Maryland, College Park, MD

*Nina Kraus, PhD*, Northwestern University, Evanston, IL

Aging is often accompanied by a loss of sensory function, leading to social isolation and frustration as communication becomes increasingly difficult. Although older adults draw on cognitive resources to fill in the gaps, declines in memory and attention may undermine their efforts to understand speech in noise. For these reasons, there has been an increased focus on auditory and/or cognitive training to improve hearing in difficult listening situations. We evaluated the effects of auditory-based cognitive training on speech-in-noise processing in older adults (ages 55 to 79). After 8 weeks of in-home training, the training group had improved subcortical speech-in-noise processing, while an active control group demonstrated no changes. In particular, in the normal hearing group we found increased trial-to-trial phase coherence in the brainstem response to a speech syllable. In the hearing impaired group, the disrupted balance of the temporal envelope and fine structure approximated that of individuals with normal hearing after training. Importantly, improvements in speech encoding were accompanied by gains in speech-in-noise perception, memory, and attention. In conclusion, central processing deficits associated with aging and hearing loss can be mitigated through training. [This work is supported by the NIH (RO1 DC01510) and the Knowles Hearing Center.]

Podium Paper III.F.

### **The Effect of Static Vestibular Schwannomas on Hearing**

*Neel Patel, MD*, University of Illinois at Chicago Medical School, Chicago, IL

*Carrie Nieman, MD*, Johns Hopkins University Medical School, Baltimore, MD

*Miriam Saadia-Redleaf, MD*, University of Illinois at Chicago Medical School, Chicago, IL

Objective: To determine the effect of static vestibular schwannomas on hearing.

Study Design: Retrospective review of audiometric measures in 12 patients with documented non-growth of internal auditory canal and cerebellopontine angle enhancing masses.

Methods: Data from patients seen in the University of Illinois Department of Otolaryngology between the years of 2002 and 2012 with a diagnosis of acoustic neuroma or vestibular schwannoma were reviewed. Exclusion criteria included pre-existing otologic disease, prior therapy for the schwannoma, and tumor growth. Radiology reports were reviewed to ensure nongrowth and were confirmed by taking MRI measurements ourselves. Audiologic measurements included pure tone average, enhanced pure tone average (average of .5, 1, 2 and 4 KHz thresholds), 4KHz threshold, 8KHz threshold and speech discrimination. The data were analyzed using mixed effect model with unstructured variance-covariance structure. Results: Audiometric measures deteriorated significantly more ( $P < 0.05$ ) in the affected ear than in the contralateral ear for all measures except 8KHz. Conclusion: Hearing declines despite no vestibular schwannoma growth. This finding can be useful for patient treatment decision making.

**PODIUM PRESENTATIONS:** Saturday, March 9, 2013

#### **PODIUM SESSION IV: PEDIATRIC SPEECH PERCEPTION; IMPLANTABLE DEVICES**

Podium Paper IV.A.

##### **Semantic Access by Speech in Children with Hearing Loss**

*Susan Jerger, PhD*, University of Texas At Dallas, Richardson, TX

*Nancy Tye-Murray, PhD*, Central Institute for the Deaf, Washington University School of Medicine, St. Louis, MO

*Markus F. Damian, PhD*, Bristol, England

This research studied whether semantic access by speech is influenced by the mode of input in children perceiving lower fidelity amplified auditory speech due to sensorineural hearing impairment (HI). Participants, 31 childrenHI and 62 children with normal hearing (NH), named pictures and ignored auditory or audiovisual word distractors. The semantic content of the distractors was varied to be related vs unrelated to the pictures (e.g., picture-distractor of dog-bear vs dog-cheese, respectively). In listenersNH, picture naming times were slower for semantically-related than -unrelated distractors, an effect called semantic interference and attributed to the distractor's and picture's semantic representations competing for control of the response. Recently, a competition threshold hypothesis (CTH) proposed that sensory input of lower fidelity does not produce the normal interference effect because poorer input is not sufficient to produce competition. This research investigated whether the proposals of the CTH generalize to the lower fidelity auditory input created by HI. Results in the childrenHI showed that only the audiovisual distractors produced the expected semantic interference. Results in the groupHI vs groupNH differed significantly for the auditory mode, but not for the audiovisual mode. Adding visual speech appears to enrich lower fidelity auditory input and promote normal semantic access.

Podium Paper IV.B.

**Family Influences on Social and Cognitive Skills in Hearing-Impaired Children**

*Rachel Holt, PhD*, Indiana University, Bloomington, IN

*Jessica Beer, PhD; William Kronenberger, PhD*, Indiana University School of Medicine, Indianapolis, IN

*David Pisoni, PhD*, Indiana University, Bloomington, IN

Despite progress in early identification and great advancements in hearing health technology, there remains a great deal of variability in outcomes in children with hearing loss. The child's family environment remains a relatively unexplored domain of influence on outcomes. Standardized measures of language, social skills, executive function, and home environment were administered to school-age children: 10 each with normal hearing, hearing aids, and cochlear implants. Parent-child interactions were video-recorded and analyzed. Language was similarly delayed in both hearing-impaired groups. Social skills, problem behaviors, and executive functioning were similar among the groups, although differences emerged in specific areas: normal-hearing children had higher levels of cooperation and responsibility, and fewer problems with externalizing, inattention, inhibition, planning and organizing, and self-monitoring than children with hearing loss. In children with hearing loss, language mediated the positive relation found between enriched home environments and working memory. Furthermore, regardless of language ability, better social skills and fewer problem behaviors were positively correlated with executive function. Finally, more enriched home environments were related to better language, and greater family integration was related to better inhibitory control and fewer problem behaviors. The results have implications for novel, targeted interventions for children with sensory aids. [Funded by Indiana University.]

Podium Paper IV.C.

**Speech-on-Speech Masking for Children: Male vs. Female Talkers**

*Lauren Calandruccio, PhD; Emily Buss, PhD; Lori Leibold, PhD*, University of North Carolina, Chapel Hill, NC

Children are more susceptible to informational masking compared to adults (Elliot et al., 1979), often requiring an improved signal-to-noise ratio (SNR) to reach similar levels in performance (Hall et al., 2002). This age effect is pronounced for a speech target competing with a speech masker. It is well documented that adults' speech recognition is better when talkers of the opposite sex rather than the same produce the target and masker speech. It is unknown, however, if children, who are significantly more susceptible to informational masking, are able to benefit from the target/masker sex mismatch cue. The goal of this project is to further our understanding of the speech-on-speech masking deficit children demonstrate throughout childhood while specifically investigating whether children can improve their speech recognition when the target and masker speech are spoken by talkers of the opposite sex. Normal-hearing children and adults were tested on a four-alternative forced-choice paradigm

that estimates bi-syllabic word identification thresholds corresponding to 70.7% correct identification in the presence of continuous two-talker speech (Hall et al.). Differences in SNR needed to equate performance between the two groups will be reported, as well as improved performance for children when the sex of the target/masker talkers are mismatched.

Podium Paper IV.D.

### **Masked Speech Detection in Infants, Children and Adults**

*Lori Leibold, PhD; Angela Yarnell, PhD; Emily Buss, PhD*, University of North Carolina, Chapel Hill, NC

Infants and children have difficulty perceiving speech embedded in competing background sounds as compared to adults. These age effects appear to reflect central, rather than peripheral, auditory processes. However, it is not clear how and when these central processes mature. This study used an observer-based psychophysical procedure to compare infants' (7-13 months), children's (4-10 years), and adults' (18-26 years) masked speech detection thresholds for bi-syllabic words produced by a female talker. Target words were presented in a continuous background of two-female-talker speech or speech-shaped noise. Maskers were presented at a fixed overall level of 50 dB SPL. Following training to an 80%-correct criterion, speech detection thresholds were measured adaptively using a 2-down, 1-up procedure. Infants' thresholds were higher than children's and adults' thresholds in the noise masker, but similar thresholds were observed across children and adults. In contrast, both infants' and children's thresholds were higher than adults' thresholds in the two-talker masker. However, infants' thresholds remained higher than children's threshold in the two-talker masker. An unexpected finding was that infants' thresholds were uniformly high in both masker conditions. These results support the hypothesis that the ability to perceive speech under complex listening conditions follows a protracted time course of development.

Podium Paper IV.E.

### **Infant Skull Properties: Implications for Soft band Bone-Anchored Hearing Systems**

*Allison Mackey, MS*, University of British Columbia, Vancouver, BC  
*William Hodgetts, PhD*, University of Alberta, Edmonton, BC.  
*Susan Small, PhD*, University of British Columbia, Vancouver, BC

Soft band bone-anchored hearing systems (BAHS) are used for infants and young children; however, there are limitations to the fitting/verification method for this population. To complicate matters, we do not understand the mechanisms responsible for frequency-dependent infant-adult differences in bone-conduction (BC) sensitivity. The objectives of this study were to investigate: (i) transcranial transmission of BC sounds by measuring sound pressure in the ear canal, and (ii) mechanical impedance of the skull for groups of infants and adults. Participants were 0-1, 1-2, 2-4, and 4-7 years of age and adults. Sound pressure was

measured in the ear canal for 500-4000 Hz BC stimuli presented at the temporal bones and forehead. Mechanical impedance was measured for a 100-10 000 Hz frequency sweep. The results indicated the greatest transcranial attenuation for the youngest infant group. All children older than 1 year showed greater attenuation from the forehead-to-ipsilateral mastoid compared to contralateral-to-ipsilateral mastoid, whereas adults showed no differences in attenuation. Infants also had significantly lower mechanical impedance compared to adults for low frequencies but similar impedances for high frequencies. These findings suggest that infant-adult differences in skull properties contribute to differences in BC sound transmission, factors that should be considered when developing BAHS fitting protocols for infants.

#### Podium Paper IV.F.

### **Self-selected Frequency Tables in Users of Bilateral Cochlear Implants**

*Matthew Fitzgerald, PhD; Katelyn Glassman, AuD; Ksenia Prosolovich, MD; Chin-tuan Tan, PhD; Mario Svirsky, PhD, New York University School of Medicine, New York, NY*

Compared to monaural cochlear implants (CI), bilateral CIs provide improved speech understanding in noise and sound localization. In current clinical practice, each implant is fit independently. This practice, however, cannot account for between-ear mismatches in insertion depth or neural survival, which could lead to a signal stimulating different regions of the cochlea in each ear. Such between-ear mismatches might be compensated for by adjusting the frequency table in one or both implants. Unfortunately, no tool exists to determine when these adjustments are necessary, and what adjustments are appropriate. Thus, we are developing a tool which allows for adjustment of the frequency table in real time. We assume that a patient may benefit from reprogramming of the frequency table if they select a table in one ear that differs from the standard table in the contralateral CI. Our data indicate that approximately 50% of individuals select a table in one ear which differs from the standard, suggesting that they may benefit from reprogramming of the CI. Moreover, the frequency-tables selected to maximize speech understanding sometimes differ from tables that elicit similar pitch percepts in each ear. This suggests that individuals may be attempting to maximize intelligibility while maintaining a natural-sounding signal.

#### Podium Paper IV.G.

### **Using SSD Listeners to Validate Acoustic Models of Cochlear Implants**

*Mario Svirsky, PhD; Nai Ding, PhD; Elad Sagi, PhD; Chin-tuan Tan, PhD; Matthew Fitzgerald, PhD NYU School of Medicine, New York, NY*

Acoustic models of cochlear implants have been used for almost three decades and have resulted in a large amount of scientific work and publications. In these models, the input signal is processed the same way as in a cochlear implant speech processor. However, the percepts that would be caused by electrical stimulation in a real cochlear implant are simulated by modulating the amplitude of either noise bands or sinusoids. A recent development has made it possible to conduct within-listener validation of these models. 'Single-sided deafness' (SSD)

listeners, who have normal or near normal hearing in the ear contralateral to the implant, allow for the first time a direct comparison of the auditory percepts caused by a cochlear implant and those caused by an acoustic model of the same device. Here we present a tool that allows SSD listeners to modify parameters of an acoustic model to make it sound as similar as possible to what they hear with the implanted ear. Preliminary results suggest that the acoustic models most commonly used in the literature may overestimate both the intelligibility and the sound quality of real cochlear implants.

Podium Paper IV.H.

### **Providing Temporal Fine Structure Cues to Cochlear Implant Users**

*Fred Apoux, PhD; Eric Healy, PhD, Ohio State University, Columbus, OH*

Over the past decade, evidence has accumulated suggesting that temporal fine structure (TFS) cues play an important role in speech recognition, especially when background noise is present. Unfortunately, cochlear implant (CI) users do not have access to these important cues as the TFS of the incoming sounds is not transmitted through their devices. Therefore, efforts have been made to deliver TFS cues to CI users. In a preliminary study, we suggested that TFS cues are not important to identify speech sounds and are instead primarily used to segregate the target from the interfering sounds. Accordingly, delivering the original TFS of the incoming sounds may not be necessary. Instead, CI devices should use various independent TFSs or carriers to promote segregation. The present study tested this hypothesis by measuring sentence recognition in normal-hearing subjects listening to a CI simulation (vocoder). The target and interfering sounds were vocoded separately using independent carriers before adding. Comparison with a traditional single carrier vocoder showed a potential 300% improvement in recognition. Compared to noise suppression, the present strategy offers the advantage of preserving the complexity of the acoustic environment while providing comparable benefits. [Work supported by NIDCD]

## **PODIUM SESSION V: LISTENING EFFORT; AMPLIFICATION**

Podium Paper V.A.

### **Reducing Listening Effort in Background Noise with Hearing Aids**

*Jamie Desjardins, PhD; Karen Doherty, PhD, Syracuse University, Syracuse, NY*

The most common complaints of hearing-impaired listeners, especially older listeners, are difficulties understanding speech in noisy environments. Even when using well-fitting amplification older hearing-impaired people need to expend more listening effort to obtain a similar speech recognition performance level in noise compared to younger listeners (Desjardins & Doherty, 2012). Directional microphones and noise reduction (NR) algorithms have both been designed to improve listening in background noise. The objective benefit provided by these two strategies has been limited. However, hearing aid users frequently

report that using these features makes it 'easier' for them to listen in noisy situations. In this study, we used a dual-task paradigm to objectively measure if directional microphones and NR, in isolation and/or combined, can reduce the listening effort older hearing impaired participants expend on a speech in noise task. Participants repeated sentences in a background masker, while tracking a moving target around an ellipse displayed on a computer screen. Participants performed the dual- task at two signal-to-noise ratio levels. Results indicated that there were no significant improvements in participants' speech intelligibility scores in several of the listening conditions however, listening effort was significantly reduced.

Podium Paper V.B.

### **In Search of a Sensitive Measure to Evaluate Listening Effort**

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

There is increasing interest in studying listening effort. While many studies have shown the effects of noise, hearing loss, and hearing aid processing on listening effort, the magnitude of these effects have generally been small. The effects are much smaller, in fact, than one might assume based on patients' reports of listening effort in clinics. This disconnect suggests a need for more sensitive measures of listening effort. The purpose of this study was to develop a reliable and valid measure of listening effort that could be included in future studies. Participants with normal hearing (n=20) and with hearing loss (n=18) were tested using three dual-task paradigms and one speech recall paradigm, all designed to evaluate listening effort. Analyses of individual and group data suggest that one of the newly designed methods is particularly sensitive to factors that affect listening effort. In addition, analyses revealed inconsistent results with another paradigm. In total, these results provide insight into the mechanisms underlying what is measured in listening effort paradigms. Furthermore, the results suggest that the most sensitive measure, which also has the best face validity, will be useful in future evaluations of the effects of hearing loss and hearing aids on listening effort.

Podium Paper V.C.

### **Measuring Listening Effort: Simple Dual-Task Paradigm vs. Car Simulator**

*Yu-Hsiang Wu, PhD; Elizabeth Stangl, AuD; Ruth Bentler, PhD, University of Iowa, Iowa City, IA*

Dual-task experiments that require the listener to simultaneously perform a speech recognition task and a secondary task have been widely used to quantify listening effort (i.e., cognitive load when listening to speech). The purpose of this study was to investigate if the effect of hearing aid technologies on listening effort measured by dual-task experiments, which used either a simple secondary task or a complicated, more real world secondary task, would be consistent. The simple secondary task was a visual reaction-time task (Sarampalis et al., 2009) conducted in a sound-treated booth, while the complicated task was driving a computerized car simulator on a rural road. The speech materials and road noises for the speech recognition task were recorded through hearing aids in a van traveling on the highway. The results obtained from 19

hearing-impaired adults indicate that, on average, the simple and complicated dual-task experiments show the same trend. However, the correlations between the two experiments are very weak. These results suggest that, for a given listener, the result obtained from a dual-task experiment may not generalize to another dual-task paradigm. The ecological validity of the dual-task experimental procedure will be discussed.

Podium Paper V.D.

## **Hearing Loss Affects Autonomic Nervous System Reactivity During Speech Recognition**

*Carol Mackersie, PhD; Imola Macphee; Emily Wilson, San Diego State University, San Diego, CA*

Hearing loss has been linked to self-reported stress, but physiological stress responses in this population are not well documented. The purpose of this paper is to describe the effects of hearing loss and noise on skin conductance and heart-rate variability, two autonomic nervous system measures associated with stress.

Fifteen adults with normal hearing and 18 adults with sensorineural hearing loss participated. Mean recognition was equalized for the two groups using an adaptive procedure. Sentences were then presented at four fixed SNRs: -6, -3, 0, and +3 dB re the SNR thresholds.

Electrocardiography and skin conductance recordings were obtained during each listening condition. Spectral HRV measures extracted from the electrocardiographic recordings included low- and high-frequency power (LF, HF) and the LF/HF ratio. Ratings of task-load and stress were obtained after each listening condition.

Recognition scores and subjective ratings were similar for the two groups. Participants with hearing loss showed a decrease in LF and HF power at lower SNRs, whereas those with normal hearing did not. Skin conductance levels were not sensitive to changes in SNR. However, skin conductance z-scores reflecting overall reactivity to noise (vs. quiet) were higher for those with hearing loss than for those with normal hearing.

Podium Paper V.E.

## **Input Dynamic Range on Speech Understanding at High Level**

*Francis Kuk, PhD, Widex-Orca USA, Lisle, IL*

The input dynamic range of a hearing aid represents the highest input level that a hearing aid can handle. For a digital hearing aid with a 16 bit analog-to-digital converter (ADC), it is typically at around 96 dB. Input above this level could saturate the ADC to result in distortion and artifacts. In addition, the functionality of some signal processing features such as a directional microphone may be compromised. Various approaches to extend this input range have been attempted with different degrees of success. Recently, a new ADC is introduced that effectively increases the input range to about 113 dB SPL before saturation. Laboratory tests using speech recorded at a high input level of 103 dB SPL (and SNR from -3 to +3 dB) showed a significantly better speech in noise score for the hearing aid with a higher input range (i.e., 113



dB SPL) than one with a lower input range (of 103 dB SPL). Details of the design, along with the study and its results will be presented.

Podium Paper V.F.

### **Application of Wind Noise Temporal Characteristics to Hearing Aid Design**

*King Chung, PhD*, Northern Illinois University, DeKalb, IL

*Kaibao Nie, PhD*, University of Washington, Seattle, WA

**Background:** Wind noise can be a debilitating masker for hearing aid users. Modulation-based noise reduction algorithms utilize temporal modulation detectors to infer the presence and absence of speech and noise. They differ in their abilities to reduce wind noise. The purpose of this study was to examine temporal characteristics of wind noise and to derive robust wind noise reduction strategies.

**Methods:** Behind-the-ear, in-the-ear, and completely-in-the-canal digital hearing aids were programmed to have linear amplification and flat in-situ frequency responses when worn on KEMAR. The frequency responses of the directional and omnidirectional microphone modes were also matched in response to a 70 dB SPL pink noise presented at 0° azimuth. Wind noise was recorded at the hearing aid outputs when the KEMAR head was placed in a quiet wind tunnel. The wind velocities were 0, 4.5, 9.0, and 13.5 m/s. A custom Matlab program that returned modulation rates comparable to published data on speech signals, was used to analyze the temporal envelope characteristics of the wind noise in one-third octave bands from 100 to 8000 Hz.

**Results and Conclusions:** The modulation rates of speech and wind noise will be reported and the implications to hearing aid designs will be discussed.

Podium Paper V.G.

### **Self-Inflating, Sound-Activated Balloon-Style Hearing Aid Coupling Device**

*Wayne Staab, PhD*, Dr. Wayne J. Staab & Associates, Dammeron Valley, UT

*Todd Ricketts, PhD*, Vanderbilt University, Nashville, TN

*Stephen Ambrose*, Longmont, Colorado

*Telani Lueder*, Vanderbilt University, Nashville, TN

**Background:** The Asius ADEL is an innovative approach to harnessing the energy from a hearing aid speaker to perform work - in this case, to inflate a folded balloon. A small diaphonic pump is attached to (integrated with) the balanced armature hearing aid speaker with negligible impact on its dimensions, power consumption, or sound quality to harvest the energy.

**Significance:** This study evaluated the applicability and performance of the ADEL as an alternative to custom earmolds. It was compared to traditional open and closed couplers, all of which were attachable to, and driven by the same RIC hearing aid.

**Methods:** Objective and subjective responses were recorded on 20 adult subjects with specific interest in the ADEL related to the fit, acceptance, security of fit, inflation time to seal, inflation

pressure, inflation maintenance, sound isolation, the occlusion effect, REAR, and acoustic feedback.

Results/Conclusions: The innovative, ADEL sound-actuated, inflatable ear seal provides measurable advantages over current commercial technology, especially in the realm of deep sealing, high power hearing aids requiring custom earmolds. The comfort advantage of the ADEL bubble allows the patient to tolerate a deep seal that minimizes the occlusion effect, provides excellent feedback suppression and sound isolation without requiring an ear impression and custom earmold fabrication.

Podium Paper V.H.

### **Characterizing Variability in Aided Outcomes**

*Jason Galster, PhD; Krishna Redemerk, AuD, Starkey Hearing Technologies, Eden Prairie, MN*

Reports of experimental outcomes are often limited to mean data and a select metric of variability around that mean (e.g., standard deviation or standard error). These more traditional methods of reporting data have the disadvantage of obscuring individual differences in the sample and hold poor face validity for the practicing clinician.

Novel data from a study that documented benefits of directional microphones on speech recognition ability will be used to facilitate discussion regarding individual variability.

Treatment conditions compared omnidirectional, fixed directional, and adaptive directional modes. It is expected that the outcomes of this study adequately represent the directional benefits of most modern hearing aids.

Contrasts will be made between different methods for data reporting with a focus on the strengths and weaknesses of each (e.g. mean data, individual data, or proportion-based box plots). Several additional metrics will be discussed, each of which is intended to characterize the effect of treatment between test conditions (e.g., effect size and number needed to treat). The aim of contrasting different forms of analysis will be to highlight those that best articulate the variability within a data set; focus will be placed on those that most clearly evidence clinically applicable outcomes.

## **PODIUM SESSION VI: IMAGING AND DISORDERS; EPIDEMIOLOGY**

Podium Paper VI.A.

### **Vestibular Related Traumatic-Brain Injury: A Preliminary Voxel-Based Morphometry Analysis**

*Anthony Cacace, PhD; Yongquan Ye, PhD, Wayne State University, Detroit, MI*

*E. Mark Haake, PhD, Detroit, Michigan*

*Faith Akin, PhD; Owen Murnane, PhD, James A. Quillen VA Medical Center, Mountain Home, TN*

Vestibular-related problems (dizziness, vertigo, and imbalance) are common sequelae following concussion and blast exposures that result in mild traumatic brain injury (mTBI). However, the

anatomical substrate connected to these dysfunctions is not well understood. To provide a better understanding of this area, we used voxel-based morphometry (VBM) as a platform for studying vestibular-related mTBI in the human brain. Briefly, VBM is a group comparison study which evaluates structural differences in magnetic resonance (MR) images between age-matched groups of individuals (11 vestibular TBI patients and 10 controls). Using the VBM-8 Toolbox and statistical probability mapping (SPM), MRI images were segmented into gray matter, white matter, and cerebrospinal fluid, normalized into a standardized anatomical space, and then analyzed statistically for significant anatomical differences between groups. Based on the VBM analysis, most notable differences in brain anatomy were characterized by reductions in gray matter volume observed in the middle frontal gyrus, mesial frontal lobe, and in the insular area in the left mesial temporal lobe. These findings provide a preliminary analysis of distributed gray matter changes in key frontal and temporal areas of the brain associated with mTBI related vestibular dysfunction.

Podium Paper VI.B.

### **Functional MRI Study of Emotion Processing in Tinnitus**

*Fatima Husain, PhD; Jake Carpenter-Thompson, University of Illinois-Urbana, Champaign, IL*

The aim of the present study was to examine differences in the engagement of the emotion processing network in individuals with tinnitus and hearing loss compared to controls without tinnitus, including those with hearing loss and those with normal hearing. We hypothesized that the normal hearing (NH) and hearing loss (HL) control groups would show increased response in the amygdala to both “Unpleasant” and “Pleasant” sounds relative to “Neutral” stimuli and that the tinnitus (TIN) group show a further increase in the response of the limbic system, especially the amygdala. A functional magnetic resonance imaging (fMRI) study was conducted using pleasant, unpleasant and neutral stimuli from the International Affective Digital Sounds database. Results revealed that the NH and HL groups showed limbic system response as expected, for the affective sounds relative to neutral stimuli. However, contrary to our expectation, the TIN group showed an increased response in insular, cingulate, and frontal cortex to affective sounds compared to neutral stimuli, but not in the amygdala. These results suggest that tinnitus may alter the emotion processing network to rely on the insula and the frontal and cingulate regions to dampen the salience of the tinnitus percept.

Podium Paper VI.C.

### **The Global Burden of Hearing Loss**

*Adrian Davis, PhD, MRC Hearing and Communication Group, London, United Kingdom*

Background: The Global Burden of Disease project looks systematically at 291 diseases and injuries to quantify the comparative magnitude of health loss due to diseases, injuries by age, sex, and geographies for specific points in time. Hearing loss has been one of the 291.

Method: Studies from around the world were quality assessed and used to provide estimates for prevalence of hearing loss including data for the USA. The burden was assessed through a weighting exercise whereby several tens of thousands of people compared the different health states (several per 291 diseases) arising from each disease including hearing loss of different severities.

Results: The results show the rising overall prevalence of hearing loss due to the ageing population of the world. The burden of disease from hearing loss was estimated as lower than previous estimates. Overall global burden of disease attributable to hearing loss has previously ranked as 12th (confidence interval 6 - 19th) in 1990 and now rates as 13th (CI 7 - 20th), after adjustment for interventions.

Discussion: There is a considerable lack of systematic, quality assessed data for hearing loss for better understanding of its impact, access to hearing healthcare and the extent to which it mitigates the burden.

#### Podium Paper VI.D.

### **U.S. Hearing Impairment Prevalence and Years Lost Due to Disability**

*Howard J. Hoffman, MA; Chuan-ming Li, PhD, Epidemiology & Statistics Program, NIH/NIDCD, Bethesda, MD*

*Robert A. Dobie, MD, San Antonio, TX*

*Christa L. Themann, MA, Cincinnati, OH*

*William J. Murphy, PhD, Hearing Loss Prevention Team, NIOSH/CDC, Cincinnati, OH*

Adult-onset hearing impairment (HI) is the third leading cause of years lost due to disability (YLD) according to the World Health Organization (WHO), Global Burden of Disease (GBD) 2004 Update. Among high-income countries, only unipolar depressive disorders, 10 million YLD (14.6%), was more common than HI, 4.2 million YLD (6.2%). YLD measures equivalent years of healthy life lost through time spent in states of less than full health. For the GBD 2010, a Hearing Loss Expert Team recommended specifying 'disabling' hearing loss as  $\geq 35$  dB HL. Mild HI was defined as better ear (BE) pure tone average (PTA) of 0.5, 1, 2, and 4 kHz, 20-34 dB HL; moderate HI, 35-49 dB HL; moderately severe, 50-64 dB HL; severe, 65-79 dB HL; profound, 80-94 dB HL; complete/deaf, 95+ dB HL. The 2010 U.S. estimate of disabling HI is 19.25 million, 6.67%. Including individuals with either ear PTA  $\geq 35$  dB HL, the U.S. prevalence increases to 34.95 million, 11.32%. Prevalence is 21% higher (12.71%) for men than for women (10.03%). Age- and sex-specific YLD curves increase steadily with age and are two-fold higher for men versus women. Hearing aid use reduces YLD 20% for men and women aged 65-79 years.

#### Podium Paper VI.E.

### **Carotid IMT and Plaque Are Associated with the Risk of Hearing Impairment**

*Karen J. Cruickshanks, PhD; David Nondahl, MS; Carla Schubert, MS; Barbara Klein, MD; Ted Tweed, MA, University of Wisconsin School of Medicine, Madison, WI*

Atherosclerosis has been suggested to be associated with aging changes in the auditory system. We evaluated the associations between two measures of atherosclerosis (mean carotid artery intima-media thickness (IMT) and the number of sites with plaque (range 0-6)) and the 5-yr incidence of hearing impairment (HI) in the Beaver Dam Offspring Study. At the baseline examination in 2005-2008, participants were ages 21-84 yrs. Hearing thresholds were measured by pure tone audiometry at baseline and the five-year follow-up (2010-2012) and atherosclerosis was measured by carotid artery ultrasound. HI was defined as a pure-tone average > 25 dB HL at 500, 1000, 2000, and 4000 Hz in either ear. In preliminary analyses of 1890 participants without HI at baseline, the incidence of HI was 8.4%. Adjusting for age, sex, and education, baseline IMT was associated with increased risk of HI (Odds Ratio (OR) per 0.1 mm = 1.17; 95% Confidence Interval (CI) = 1.04, 1.32). Plaque count was also associated with risk of HI (adjusted OR= 1.21; 95% CI=1.02, 1.44). These results suggest atherosclerosis increases the risk of developing hearing impairment. Treatments which slow the development and progression of atherosclerosis may help to slow the loss of auditory function with aging.

#### Podium Paper VI.F.

### **Prospective Study of Alcohol Use and Hearing Loss in Women**

*Sharon Curhan, MD, Channing Laboratory, Boston, MA*

*Roland Eavey, MD, Vanderbilt Bill Wilkerson Center, Nashville, TN*

*Molin Wang, PhD; Stamfer Meir, MD; Gary Curhan, MD, Brigham and Women's Hospital, Boston, MA*

**Background:** Previous studies suggest alcohol consumption may influence the development of hearing loss (HL), but results have been inconsistent.

**Methods:** We prospectively examined the independent association between alcohol intake and self-reported HL in 72,063 women, 27-44 years at baseline, from 1991-2009. Participants completed detailed questionnaires every four years. Cox proportional hazards regression was used to adjust for potential confounders.

**Results:** During the study period, 12,126 cases of hearing loss were reported to have occurred. There was a U-shaped relation between alcohol consumption and risk of HL. Compared with those who consumed alcohol less than once/month or never, the multivariate-adjusted hazard ratios (95% CI) were 0.98(0.94-1.02) for women who consumed 1-4 grams/day of alcohol, 0.95(0.90-1.00) for 5.0-14.9 grams/day, 0.90(0.83-0.97) for 15.0-29.9 grams/day, and 0.97(0.87-1.08) for 30+ grams/day. We also examined the multivariate adjusted associations with specific alcoholic beverages. Compared with women who consumed <1 serving/week, the risk of HL for 5-7 servings/week of beer was 24%(4-48%) higher, whereas the risk for 5-7 servings/week of wine and liquor were 12%(4-19%) and 22%(6-34%) lower, respectively.

**Conclusions:** Low-moderate overall alcohol consumption is associated with a reduced risk of HL in women, although the risk may differ by type of alcoholic beverage.

#### Podium Paper VI.G.

## **Hearing Impairment Is Associated with Depression in US Adults**

*Chuan-Ming Li, PhD*, National Institute on Deafness and Other Communication Disorders, Bethesda, MD

*Xinzhi Zhang, PhD*, National Institute on Minority Health and Health Disparities, Bethesda, MD

*Mary Frances Cotch, PhD; Roy Wilson, MD*, Bethesda, Maryland

*Howard Hoffman, MA*, National Institute on Deafness and Other Communication Disorders, Bethesda, MD

The relationship between hearing impairment (HI) and depression has not been reported in a nationally-representative sample. We investigated the association among US adults aged  $\geq 18$  in NHANES 2005-2010. Depression was measured by Patient Health Questionnaire (PHQ-9). By self-report, 22.1% indicated 'A little trouble' or greater HI. The prevalence of depression (PHQ-9 score  $\geq 10$ ) was 4.8% for 'Excellent' hearing, 7.0% for 'Good' hearing, 11.0% for 'A little trouble', 11.5% for 'Moderate trouble', 12.3% for 'A lot of trouble', and 5.1% for 'Deaf'. Controlling for covariates, multivariate odds ratios [OR] for depression were: 'A little trouble' 1.9 (95% confidence interval [CI], 1.4-1.7); 'Moderate trouble' 2.0 (95%CI, 1.5-2.9); 'A lot of trouble' 2.0 (95%CI, 1.2-3.2); 'Deaf' 0.6 (95%CI, 0.1-3.2). 'Excellent' was the reference group. Hearing levels (HL) based on air-conduction, pure tone average (PTA) of thresholds at 0.5, 1, 2, and 4 kHz was available for those  $\geq 70$ . Among females, moderate HI in the better ear [PTA 35-49 dB HL] was significantly associated with depression (OR=8.2; 95%CI: 1.2-55.5). Even considering concomitant health conditions, including vision impairment, HI is significantly associated with depression, particularly in women. Health care professionals should be aware of the increased risk of depression among those with HI.

Podium Paper VI.H.

## **Exchange Rate for Noise Exposure: The Human NIPTS Data**

*Robert A. Dobie, MD*, University of Texas Health Science Center, San Antonio, TX

*William Clark, PhD*, Washington University School of Medicine, St Louis, MO

Specifying an appropriate exchange rate (ER) for occupational noise standards has remained a controversial topic since the infancy of federal noise regulations in the United States, with many individuals and groups advocating for a more conservative 3 dB ER to replace the current value of 5 dB. The "acid test" for an exchange rate (ER) is its fit with studies of noise-induced permanent threshold shift in people with intermittent or fluctuating daily exposures. Most advocacy for a 3-dB ER has relied, directly or indirectly, on Passchier-Vermeer's (1973) review of 11 such studies, which concluded that the 3-dB ER fit the data reasonably well (but did not compare any other ER). We reviewed all of these studies, and included papers from our own files and from a PubMed search (excluding papers limited to impact/impulse exposures). Very few papers included enough information to allow comparison of different ERs (e.g., 3-dB vs. 5-dB); often, exposure documentation was so scanty that no average exposure value could be calculated. Available data suggest that the 3-dB ER overestimates risk for intermittent or fluctuating exposures, but do not prove that a different ER (e.g., 5-dB) would provide a

significantly better fit.