POSTER ABSTRACTS

Topic areas, poster numbers, and abstract codes:

Topic Area	Poster Numbers	Abstract Code
Anatomy and Physiology	Poster #1 – Poster #3	(ANAT01-03)
Auditory Processing	Poster #4 – Poster #14	(AP01-11)
Cochlear Implants	Poster #15 – Poster #27	(CI01-13)
Diagnostic Audiology/Otology	Poster #28 – Poster #32	(DX01-05)
Electrophysiologic Responses	Poster #33 – Poster #45	(ELECT01-13)
Hearing Loss/Rehabilitation	Poster #46 – Poster #49	(HLREH01-04)
Hearing Science/Psychoacoustics	Poster #50 – Poster #59	(HSPSY01-10)
Hearing Technology/Amplification	Poster #60 – Poster #77	(AMP01-18)
Pediatric Audiology/Otology	Poster #78 – Poster #82	(PED01-05)
Physiology: Middle Ear and Cochlea	Poster #83 – Poster #101	(PHYS01-19)
Speech Perception	Poster #102 – Poster #118	(SP01-17)
Vestibular	Poster #119 – Poster #122	(VEST01-04)

ANATOMY AND PHYSIOLOGY

Poster #1 – ANAT01
Illustrative Analyses of Human Auditory Cortex Anatomy & Its Variance
Frank Musiek, PhD; Jennifer Gonzalez; Julianne Ceruti; Kristin Geissler; Erin Lazar,
University of Connecticut, Storrs, CT

The structure of the human auditory cortex and the immediate area surrounding it is complex and often misunderstood. This anatomy will be analyzed with the use of original laboratory dissection pictures, 3-D representations and illustrations to create visual images that provide insight to normal auditory cortex variations in the human brain. In particular, examples of one, two and three Heschl's gyri in a single brain will be shown along with their morphological characteristics that influence neighboring structures such as the planum temporale, planum polare, supramarginal gyrus and angular gyrus. Also shown will be anatomical metrics of hemispheric symmetry and asymmetry of Heschl's gyrus and the planum temporale. Detailed anatomy along the Sylvian fissure will be highlighted to demonstrate its varied course from the temporal pole to the supramarginal gyrus. This Sylvian fissure anatomy will provide a basis for introducing and defining terms such as the ascending, horizontal and descending ramus. These various rami have profound implications in regard to the loci of the auditory cortex and related structures. In addition, examples of pathological conditions of the auditory cortex will be presented along with clinical central auditory test findings.

Poster #2 – ANAT02 - **T35 Research Trainee Poster**
Strial Capillary Permeability and the Role of Active Molecular Transport Mechanisms
Veronica Henson, BA; Kevin Ohlemiller, PhD,
Washington University School of Medicine, St. Louis, MO

Control of the passage of molecules from capillaries to the stria vascularis is an indicated requirement for the endocochlear potential. Previous research has shown passage of tracers including horseradish peroxidase [HRP], IgG and albumin from strial capillaries via pericellular leakage, which is purported to injure the stria and undermine the endocochlear potential. The authors alternatively propose an active process involved, such as transcytosis. The purpose of the present study was to assess the permeability of strial capillaries to fluorescently tagged molecular tracers in a way that abnormal pericellular leakage and active transport could be distinguished. Tracers tested include FITC dextran, sodium fluorescein, fluorescently tagged IgG and albumin, and CY-3 tagged HRP. CBA/J and C57BL/6J mice aged 2-6 months were deeply anesthetized and intracardially injected with one of the selected tracers while the heart continued to beat. After 5 minutes, animals were injected with 4% paraformaldehyde fixative, and the cochleae extracted. The strial and spiral ligament were removed and mounted on slides, then assessed by confocal microscopy. Multiple images were collected at a variety of magnifications for each sample, from basal and apical regions. With the exception of FITC dextran (which is not generally transported by transcytosis), all tracers appeared dispersed throughout the intra-strial space. There was no indication of strain dependence on the dispersion of any tracer. If animals were perfused intracardially with fixative prior to the introduction of any tracer, little or no tracer was found in the stria or ligament. The stria vascularis is critical for maintenance of the endocochlear potential, and therefore critical for hearing. Our observations agree with previous reports of passage of large molecules from strial capillaries into the strial lumen. However, the present work is consistent with a role for an active and regulated transport process—possibly transcytosis—and not a passive and unregulated pericellular process.

Poster #3 – ANAT03

Morphologic Variations of Clinically Normal Mallei and Incudi

N. Wendell Todd, MD; Pedram Daraei, BS,
Emory University College of Medicine Atlanta, GA

Background: Wide ranges of sizes and shapes of malleus and incus are reported in various human populations. Unaddressed are bilateral symmetry of features and shapes, whether they correlate with otitis media, and morphologic concordance of malleus and incus.
Objectives/Hypotheses: To qualitatively describe features and shapes of mallei and incudi in another population. 1) A cranium's malleus and incus features and shapes have bilateral symmetry. 2) Features and shapes of malleus and incus are unrelated to the mastoid size indicator of childhood otitis media. 3) An ear's malleus and incus are concordant.
Materials and Methods: Post-mortem material-analysis of 41 adult crania without clinical otitis media.
Results: Features and shapes of clinically normal mallei and incudi varied. Most mallei had a lateral process and inflected tip of manubrium. Most incudi had concave superior border of posterior process, non-notched inferior border of posterior process, and long process anterior edge curving posteriorly. Only one feature, absent lateral process of malleus, suggested a relationship to small mastoid size (P=.01 for right ears; no left ear specimen lacked a lateral process). No morphologic concordance of malleus and incus was found.
Conclusions: Clinically normal mallei and incudi have impressive feature and shape variations that are mostly bilaterally symmetric.

AUDITORY PROCESSING

Poster #4 – AP01

Auditory Measures Predict Teacher Ratings of Hearing Impaired Children

Stephanie Nagle, PhD, Towson University, Towson, MD
Frank Musiek, PhD, University of Connecticut, Storrs, CT

Children with permanent minimal-mild hearing loss are at substantial risk for academic delays and difficulties. Teacher ratings of these children can provide valuable insight into these difficulties. Additionally, accurate prediction of these classroom scores would allow for more precise intervention in at-risk children with minimal-mild hearing loss. This study examined the relationship between various peripheral and central auditory measures and SIFTER ratings from classroom teachers for ten children with permanent, bilateral minimal-mild hearing loss and ten age and gender matched peers. Peripheral measures included pure-tone thresholds, SRTs, and word recognition scores. Central measures included scores on behavioral APD tests and latency/amplitude measures for the MLR. The hearing impaired children were rated significantly lower than the normal hearing children in the Communication and Academics domains of the SIFTER. Correlations showed that both SRT and right dichotic digits (RE-DDT) scores were significantly correlated with scores in these domains. RE-DDT score was a significant predictor of SIFTER ratings in both areas. The addition of SRT as a predictor to the model for Communications ratings was also significant, and SRT and RE-DDT score combined were able to account for ~70% of the variance in Communication ratings. The important clinical implications of these results will be discussed.

Poster #5 – AP02

Variable Performance on Auditory Temporal Processing Tasks in Typically-Developing Children

Tina Grieco-Calub, PhD, Northwestern Unviersity, Evanston, IL
Whitney Lowe, AuD, Northern Illinois University, Dekalb, IL
Heidi Kluga, MS, DeKalb, IL

Protocols designed to evaluate auditory processing in children often vary across clinics, and tests that measure the same auditory skill are frequently interchanged. For example, auditory temporal processing, the ability to resolve sequential auditory information, can be evaluated with one of three commercially-available tests: Random Gap Detection (RDGT), Frequency Pattern (FPT) and Duration Pattern (DPT). The purpose of this study was to determine if typically-developing children can perform these tasks equivalently. Twenty-five children between 7-and-11 years of age with no history of peripheral or central auditory disorders completed the RDGT, FPT and DPT. Test presentation was randomized to control for order effects. Results revealed that all children preformed within the normal range for each task; however, within-subject variability in performance across tasks was observed. A mixed-design analysis of variance revealed significant effects of patterning task (within-subjects variable) and age (between-subjects variable). Children performed significantly better on the FPT than the DPT. In addition, seven-year-old children performed significantly poorer than 9-to-11 year olds on both tasks. There was no correlation in performance across the RGDT, FPT and DPT, suggesting that children performed better on some tasks than on others. Practical considerations for testing auditory processing in children will be discussed.

Poster #6 – AP03 - **Mentored Student Research Poster Award**

Utility of Auditory-Visual Cues in Short-Term Working Memory

Lynn Bielski, MA (Mentored Student); Charissa Lansing, PhD,
University of Illinois at Urbana, Champaign, IL

It is well known that visual cues from the talker's face improve speech understanding, particularly in background noise. Less is known about the utility of these cues for short-term working memory (STWM). If STWM is critical for speech understanding, then visual cues would also benefit STWM performance. Similarly, visual cues should reduce perceptual effort in noise. Normal hearing, young and older adults, and children listened to word strings in a running memory task that required encoding, rehearsal and maintenance functions. Word strings were presented in quiet and in noise, with and without the talker's face. Performance was examined within the framework of a STWM model with components for phonological and visual information. Errors rarely occurred for the last word heard, indicating high speech intelligibility, compared to the number of errors for words further back in the string, indicating a STWM effect. Across all groups, fewer recall errors were made with visual cues present. The hypothesis that visual cues benefit STWM, especially in noise, was supported in most but not all listeners, highlighting the importance of individual evaluation. Compared to auditory-only conditions, frustration ratings were lower in auditory-visual conditions which may be associated with reduced perceptual effort.

Poster #7 – AP04

Auditory Processing Phenotype of Neurofibromatosis Type I

Lucas Lancaster, Gallaudet University, Washington, DC
Kelly King, PhD; Christopher Zalewski, MA, NIH/NIDCD, Bethesda, MD
Brigitte Widemann, MD; *Pamela Wolters, PhD; Staci Martin, PhD; Andy Gillespie, BSN; Eva Dombi, MD,* NCI, Bethesda, MD,
Carmen Brewer, PhD, NIH/NIDCD, Bethesda, MD

Neurofibromatosis type I (NF1) is a relatively common autosomal dominant, progressive neuro-cutaneous disorder resulting from mutations of NF1, the gene responsible for production of the tumor suppressing protein, neurofibromin. Persons with NF1 have increased risk of developing central and peripheral nervous system tumors, in addition to cutaneous, skeletal, vascular and cognitive manifestations. We previously reported abnormal ABRs in 7/28 individuals with NF1, 5 of whom had evidence of spongiform gliosis on MRI. The current study characterizes auditory processing (AP) abilities of persons with NF1, and evaluates associations with other aspects of the phenotype. We hypothesized that 1) NF1 is associated with risk for AP deficits, and 2) concomitant CNS structural abnormalities and/or neurodevelopmental disorders overlap AP disorders in this group. We evaluated 44 individuals with NF1, aged 7-29 years (mean 15.7; SD 5.25) with normal hearing sensitivity using linguistic and non-linguistic behavioral measures of AP and ABR. Reduced performance was observed on at least two AP tests in 68% and at least one linguistic and one non-linguistic test in 44% of our cohort. We compare behavioral AP results with findings on ABR, CNS imaging and neuropsychological tests, and discuss the implications on developmental and educational success of individuals with NF1.

Poster #8 – AP05

Binaural Masking Release in Children with Down Syndrome

Heather Porter, PhD; D. Wesley Grantham, PhD; Anne Marie Tharpe, PhD,

Vanderbilt University, Nashville, TN

Listening advantages, such as improved speech understanding in noise, are facilitated in part by binaural hearing. Children with Down syndrome have anatomical abnormalities within the auditory system that could impact binaural hearing. This study tested the hypothesis that children with Down syndrome experience less binaural benefit than typically-developing peers. Participants included children with Down syndrome aged 6 to 16 years (N=11), typically-developing children aged 3 to 12 years (N=46), adults with Down syndrome (N=3), and adults with no known neurological delays (N=6); all participants had normal hearing sensitivity. Two tasks were employed: 1) a masking level difference (MLD) task using 500-Hz pure tone signals, and 2) a binaural intelligibility level difference (BILD) task using speech signals. Children with Down syndrome had higher masked thresholds for pure tones and speech stimuli, and reduced MLDs compared to typically-developing children. Significant differences in MLD were not observed for adults with Down syndrome and control adults. Children with Down syndrome experienced less binaural benefit than typically-developing children suggesting that they require more favorable signal-to-noise ratios to achieve optimal performance in adverse listening conditions. This could be due to delays in the development of binaural hearing rather than a deficit that persists into adulthood.

Poster #9 – AP06

Auditory Processing in Individuals on the Autism Spectrum

Kathryn Hope; Linda Norrix, PhD; Kelly Morales; Feng-yi Chuang; David Velenovsky, PhD,
University of Arizona, Tucson, AZ

Individuals with central auditory processing disorders (CAPD) have normal hearing but exhibit deficits in selective auditory attention and listening in noise. Individuals on the autism spectrum often have difficulties with speech perception, and their communication deficits have led to the hypothesis that they have CAPD. One model of CAPD, bottom-up, 'stimulus driven processing' posits that incoming stimuli are degraded by noise. Another model assumes that top-down, higher level cortical-mediated processes contribute to the listening difficulties in this population. In this study we explore the effects of both 'top-down' control mechanisms and 'bottom-up' aspects of auditory processing and characterize these effects in individuals with autism spectrum disorder. We evaluated 10 control subjects and 2 young adults with ASD using a variety of measures. Presently, we are continuing to evaluate ASD subjects. Our test battery includes contralateral suppression of otoacoustic emissions, speech-in-noise understanding, dichotic listening abilities (coordination or selective listening with both ears), and sustained auditory attention. To address a possible relationship between visual and auditory attention, the Attention Network Test was administered. Between-group comparisons will be made on all tasks. These data are important for defining the mechanism(s) underlying listening difficulties in those on the autism spectrum.

Poster #10 – AP07

Auditory Processing Abilities in Adults with High Functioning Autism

Jennifer Smart, PhD; Allison Godlewicz; Stephanie Nagle, PhD; Donna Long, MS,
Towson University, Towson, MD

Adults with autism spectrum disorder (ASD) have auditory complaints that aren't explained by their pure tone audiogram. Therefore, further investigation into why these complaints may occur was warranted.

Both the peripheral and central auditory nervous systems of nine adult males with ASD and nine typically developing age and gender matched controls were evaluated. A comprehensive audiological evaluation was performed prior the auditory processing disorder (APD) tests. The control group scored higher on all of the APD tests, but only significantly higher on the AFG +8 task. A discussion about ASD and APD will be given.

Poster #11 – AP08

Decreasing Test Time for Gap Detection Tests: A Pilot Study

Stephanie Nagle, PhD, Towson University, Towson, MD
Shannon Palmer, PhD, Central Michigan University, Mt. Pleasant, MI
Frank Musiek, PhD, University of Connecticut, Storrs, CT

The Gaps-in-Noise (GIN) test is one of the only commercially available tests of temporal resolution that is sensitive and specific to lesions of the central auditory nervous system. As such, the GIN is a powerful clinical tool for temporal resolution assessment. It is under-utilized by clinicians, however, due to required test time (20-25 minutes). This was a pilot study comparing the full-length clinical GIN to a shorter, screening version of the GIN as well as a computer-based, adaptive gap-detection test (AGDP) with the GIN stimuli. Both the screening GIN and the adaptive method result in substantially shorter test times. Test order was randomized and had no significant effect on results. Results from 10 subjects who underwent all three test procedures showed significant differences between results obtained with the full GIN and the screening GIN. In contrast, results obtained using the adaptive method were not significantly different from either the full GIN or the screening GIN results. Use of the screening GIN and the adaptive test as potential screeners was examined as well. Neither the adaptive method nor the screening GIN were particularly effective as screening measures. These results have important clinical implications for timely assessment of temporal resolution.

Poster #12 – AP09

Measurements in Listening Effort for Younger and Older Normal-Hearing Listeners

Jeffrey DiGiovanni, PhD; Naveen Nagaraj, MA; Laura Stephens, AuD,
Ohio University, Athens, OH

This study examined the effects of listening effort on auditory working memory performance while controlling for speech intelligibility. The aim of the current study was to measure listening effort in younger and older normal-hearing listeners using language-based attention switching and working memory tasks. Attention-switching and dual-task paradigms were assessed in quiet and in multi-talker-babble (MTB). 20 elderly (50-68 years) and 29 young (18-32 years) normal-hearing adults participated in this study. During the attention-switching task, subjects listened to multiple sequences of digits. The digits were placed into low (1 - 4) and high (6 - 9) categories. Subjects were asked to mentally tally the number of high and low digits presented and recall the total in each category. For the dual-task, listeners were presented with a set of sentences. Before each sentence in the set, a digit was presented. After each sentence, they were asked to respond whether the sentence was 'True' or 'False'. At the end of each set, the subjects were instructed to recall the digits. Performance in MTB condition for both group produced degraded performance in accuracy and reaction time due to an increase in listening effort. Findings also highlighted an increased cognitive load for the elderly.

Poster #13 – AP10

Effects of Age on Behavioral and Electrophysiologic Binaural Auditory Performance

Christina Roup, PhD, Ohio State University, Columbus, OH
Elizabeth Leigh-Paffenroth, PhD, Madison Veterans Affairs Medical Center, Madison, WI

The purpose of the present study was to examine the effects of age on behavioral and electrophysiologic measures of binaural auditory performance. Sixty-two listeners with symmetrical hearing were tested and grouped by age: young adults (23-39 years), middle-age adults (40-59 years), and older adults (60-80 years). Behavioral performance was measured by the 500 Hz masking level difference (MLD) and 3-pair dichotic digit recognition. The electrophysiologic responses were assessed by the binaural interaction component (BIC) of the middle latency response. Results revealed that behavioral measures of binaural auditory processing (MLD and dichotic ear advantage) were significantly correlated to the BIC Na-Pa amplitude across all age groups. A significant difference in binaural auditory performance due to age was present for the dichotic ear advantage only (older adults exhibited a significantly larger ear advantage than did young adults). Individual results for five listeners demonstrated poor binaural auditory performance for two of the three variables. Binaural auditory performance was consistent for most listeners regardless of age. For some listeners in the middle-age and older adult groups, however, binaural auditory performance was abnormal and may be an indication of binaural auditory processing deficits. These listeners may benefit from alternative forms of audiologic rehabilitation.

Poster #14 – AP11

Explaining Listening Comprehension Variability Using Cognitive and Speech Tests

Naveen Nagaraj, MA; Jeffrey Digiovanni, PhD,
Ohio University, Athens, OH

Clinical research in hearing science has focused primarily on speech intelligibility measures which index how well an individual can recognize and repeat what is heard. However, the complex nature of listening comprehension processes cannot be understood completely by currently used word recognition and sentence recognition tasks. The focus of this study is to account for individual variability in listening comprehension using traditional word- and sentence-recognition tests and novel working memory (WM) span and controlled attention tasks. Forty adults with normal hearing abilities between 18 - 40 years took part in this study. Listening comprehension was measured using passages. Measures such as word and sentence recognition thresholds, reaction time, and accuracy from WM and controlled attention tasks were used to explain the individual variability in listening comprehension scores. The predictive value of the traditional auditory tests and the novel cognitive tasks were examined using General Linear Model and discussed for quiet and noise conditions. Findings from this study explain how listening comprehension in quiet and noise is impacted by cognitive aspects such as short-term memory, WM, and attention switching. These findings support the notion that new tests which incorporate various aspects of cognition will provide useful information along with traditional speech tests.

COCHLEAR IMPLANTS

Poster #15 – CI01

Acoustic Properties of Vowel Production in Children with Cochlear Implants
Emily Brown, BS, Ohio University, Athens, OH
Jing Yang, The Ohio State University, Columbus, OH
Li Xu, PhD; Rebecca Berger

Previous studies have shown that tone development in Mandarin-speaking children with cochlear implants is compromised due to inadequate pitch information delivered through the multichannel cochlear implant devices. It is important to understand vowel development under the condition of suboptimal tone development in those children. The purpose of the present study is to investigate the acoustic properties of vowel production in Mandarin-speaking children with cochlear implants. Monosyllabic speech tokens that included Mandarin vowels (/a i u y '/) were recorded from 14 prelingually-deafened children (2.9 - 8.3 years old) who received cochlear implants. Sixty normal-hearing children of a similar age range were recruited as controls. Formant frequencies at three temporal locations over the course of vowel duration are measured using a spectrographic analysis program (TF32). Both static (vowel duration, midpoint formant frequency values) and dynamic (trajectory length, spectral rate of change, dispersion pattern of formant track) acoustic properties of the vowels are compared between the normal-hearing and cochlear-implant children. While the data analysis is on-going, the presentation will include completed report of the results. We will test the hypothesis that vowel production of children with cochlear implants varies greatly on acoustic parameters when compared to that of normal hearing peers.

Poster #16 – CI02 - **T35 Research Trainee Poster**
Recognition of Child-directed Emotional Speech by Normally Hearing Listeners
Danielle Zion, AuD, University of Maryland, College Park, MD
Monita Chatterjee, PhD, Boys Town National Research Hospital, Omaha, NE

The long-term goal of this project is to investigate vocal emotion recognition by children with cochlear implants. Recordings were made of 4 talkers (2 male, 2 female) productions of 27 semantically neutral Hearing in Noise Test (HINT) sentences, spoken with the 5 target emotions (angry, happy, neutral, sad, and scared) in a child-directed speech style. Acoustic analyses of these recordings confirmed some of the expected differences between the child-directed speech and previous findings for adult-directed speech (e.g., higher mean voice pitch and wider overall pitch range). A subjective validation task was completed with 20 normally hearing (NH) adult listeners, revealing high (91% correct) overall recognition performance, consistent with previous studies. Preliminary results with 8 NH children (age 7-16 years) indicate similarly high overall recognition. Emotion recognition by 7 cochlear-implanted (CI) adults (age >25 years) and 3 CI children (age 11-17 years) was better than chance but lower and more individually variable than their NH counterparts. It is hypothesized that this difference in performance is due at least in part to cochlear implant users' limited access to the relevant acoustic cues for vocal emotion recognition. [Work supported by NIH/NIDCD grant nos. T35 DC008757 and R21 DC011905]

Poster #17 – CI03 - **T35 Research Trainee Poster**
Multisensory Processing in Children with Cochlear Implants
Amelia Shuster, BS; Ryan Stevenson, PhD; Mark Wallace, PhD,
Vanderbilt University, Nashville, TN

Introduction: The ability to integrate information from multiple sensory inputs is vital to understanding the world around us. Children who use cochlear implants receive degraded auditory information, so integration of auditory with other sensory information may be affected. This study investigates whether children with cochlear implants integrate audiovisual information differently than children with normal hearing. Methods: Subjects were seven children with cochlear implants and five children with normal hearing from 6 to 13 years old. Audiovisual integration was assessed using auditory, visual, and audiovisual tasks. Results: In the simultaneity judgment tasks, children with normal hearing demonstrated more precise multisensory temporal processing, a key aspect of integration. Children with normal hearing performed better in unisensory tasks and perceived multisensory illusions more frequently than children with cochlear implants. However, children with cochlear implants showed greater gain in speech recognition when both auditory and visual information were available compared to unisensory conditions, a common finding in normal hearing children listening to a degraded signal. Discussion: This study showed differences in auditory, visual, and audiovisual processing in children with cochlear implants and children with normal hearing. Further research will investigate the effects of age on audiovisual integration. [Supported by NIH-NIDCD T35DC008763 and NIH-NIDCD F32DC011993]

Poster #18 – CI04

Independent Component Analysis: Cochlear Implant Artifact Removal in EEG Data

Sharon Miller, MA; Yang Zhang, PhD, University of Minnesota, Minneapolis, MN

Auditory event-related potentials (ERPs) can examine the neural processing of complex speech and non-speech stimuli and are an attractive tool for assessing outcomes in cochlear implant (CI) listeners. However, large CI-induced electrical artifacts are generally present in every stimulus trial, obscuring the underlying cortical activity for proper data interpretation. The present study utilized Independent Component Analysis (ICA) to analyze ERP responses in CI users. Both a manual artifact removal procedure and a new semi-automatic CI artifact attenuation technique (CIAC) (Viola et al., 2012) were implemented to assess whether the two different analysis techniques would produce similar and reliable peak amplitudes and latencies in the resultant ERPs. The EEG data were recorded in an electrically shielded sound booth to a 1000 Hz tone and synthetic /ba/, /da/, /wa/, and /ja/ speech stimuli. Data analysis was performed using the EEGLAB toolbox, the CIAC plug-in, and additional in-house Matlab functions. The results showed overall consistency in ERP peak amplitudes and latencies across the two analysis techniques, suggesting that both are useful methods for reducing the CI artifacts from ERP responses.

Poster #19 – CI05

Pitch and Phoneme Perception in Cochlear-Implant Users

Ray Goldsworthy, PhD, Sensimetrics Corporation, Malden, CA
Amy Martinez, MA, House Research Institute, Los Angeles, CA.

Musical pitch and speech perception in noise are relatively difficult for cochlear-implant (CI) listeners compared to their normal-hearing (NH) peers. The purpose of this study was to examine relations between such measures. Measures of frequency discrimination included harmonic-frequency and tonal-frequency discrimination using a 3-interval, alternative forced-choice adaptive procedure. Harmonic complex frequency discrimination was tested at standard frequencies of 110, 220, 440 Hz in a filtered region near 1000 Hz. Tonal frequency discrimination was tested at standard frequencies of 500, 1000, and 2000 Hz. The effects of amplitude and frequency roving of stimuli were examined. Measures of

phoneme perception included consonant and vowel identification in quiet, as well as in three noise conditions: 1) stationary, 2) temporally-gated, and 3) spectrally-notched speech-shaped noise. Results illustrate a wide range in performance across CI listeners and provide further evidence that CI listeners obtain less masking release in temporally-gated noise compared to their NH peers. However, contrary to previous studies, we found CI listeners do experience a degree of masking release in temporally-gated noise, with average masking release of approximately 4 dB for consonants and 8 dB for vowels. Correlations between psychoacoustic pitch and phoneme perception measures will be examined.

Poster #20 – CI06 - **T35 Research Trainee Poster**

Evaluation of Cochlear Implant Fine Structure Processing for Spatial Hearing

Mary Easterday, MS, University of Tennessee Health Science Center, Knoxville, TN
Rene Gifford, PhD; D. Wesley Grantham, PhD, Vanderbilt University, Nashville, TN
David Haynes, MD; Robert Labadie, MD, Vanderbilt University Medical Center, Nashville, TN
Betty Tsai, MD; Daniel Ashmead, PhD, Vanderbilt University, Nashville, TN

Cochlear implant recipients exhibit poorer sound localization than listeners with normal hearing. One contributing factor is that traditional envelope-based processing strategies discard the temporal fine structure of the signal. Without this information, and lack of processor synchronization, implant users cannot access interaural time difference cues, which are extremely useful for sound localization. The objective of this study was to assess the efficacy of fine structure processing (FSP) as compared to high definition continuous interleaved sampling (HDCIS) for Med El implant recipients. Six spatial hearing tasks were used for within-subjects comparisons in 12 adult bilaterally implanted listeners. Six age-matched normal hearing listeners served as control. The tasks were directional localization in free field, minimum audible angle, interaural time difference thresholds, interaural level difference thresholds, motion path perception in free field, and on-the-street alignment for road crossing based on vehicle sounds. Hearing group differences, favoring listeners with normal hearing on all tasks, were consistent with previous reports. Among implant users, performance was not significantly different for the HDCIS and FSP conditions, and within-task correlations between these conditions were high. These findings suggest that the current implementation of FSP-without processor synchronization provides little to no benefit for various aspects of spatial hearing.
[Supported by NIH-NIDCD T35DC008763]

Poster #21 – CI07

Adaptive-Bandwidth Measurement of Importance Functions with CNC Words

Nathaniel Whitmal, PhD; Decia Demaio; Erin Bean,
University of Massachusetts, Amherst, MA

Cochlear implants encode sounds for users via electrode arrays that stimulate auditory neurons. Despite successes in improving speech perception, methods for evaluating individual electrode channels' contributions remain elusive. Recent implant simulation experiments with normal-hearing listeners (Whitmal and DeRoy, 2012) show that frequency importance functions (FIFs) successfully quantify channel contributions to speech perception. Yet, speech perception scores and FIFs for listeners using 6-8 channels showed higher variability than data for listeners using 12 or more channels, despite more extensive training. These variations are presumably related to the vowel-consonant vowel (VCV) stimuli used, and may confound measurements of clinically-relevant variations in implant users. The present study evaluates the use of consonant-nucleus-consonant (CNC) words for adaptive-

bandwidth FIF measurement in implant simulations. CNC words were chosen for three reasons: common use in implant evaluations, suitability for automatic scoring, and compatibility with FIF computation despite their lexical content (Henry et al., 1998). Results show that CNC-based FIFs have lower intra- and inter-subject variability in adaptive runs than VCV-based FIFs. FIF 'crossover' values are located approximately one octave below those observed for VCVs; further shifts associated with the loss of pitch information in VCVs are absent for CNCs. Implications of this latter result will be discussed.

Poster #22 – CI08

Assessment of Spectral Resolution for Speech: Implications for Cochlear Implants

Matthew Winn, PhD; Ruth Litovsky, PhD,
University of Wisconsin-Madison, Madison, WI

We introduce a battery of tests designed to assess a listener's spectral resolution for speech sounds. This has historically been difficult because of acoustic redundancy of speech contrasts. For this study, we orthogonally manipulated acoustic cues in natural speech stimuli to evaluate how listeners 1) use spectral cues like formant patterns, 2) compensate by falling back on secondary cues, and 3) use spectral cues to modulate the perception of temporal cues.

Speech identification results were modeled using logistic regression; psychometric function slope was used as a metric of cue resolution. Bilateral cochlear implant listeners were tested using (a) their clinical maps and (b) novel maps featuring interleaved bilateral channel frequency allocation tables designed to reduce channel interaction.

Listeners using the bilateral interleaved maps showed significant improvement in spectral resolution for numerous tasks. Specifically, their use of primary spectral cues improved, and their reliance upon secondary cues decreased. We highlight the novel finding that performance became more like that of listeners with normal hearing, with no explicit training involved.

To the extent that improvements in CI speech coding are driven by innovations in spectral resolution, we propose that this test battery can serve as an assessment tool to evaluate new technology.

Poster #23 – CI09

Bimodal Cochlear Implants: The Role of Acoustic Signal Level

Michael F. Dorman, PhD, Arizona State University, Tempe, AZ
Philip Loizou, PhD, University of Texas at Dallas, Richardson, TX
Shuai Wang, Ting Zhang, PhD, Tony Spahr, PhD, Louise Loiselle and Sarah Cook,
Arizona State University, Tempe, AZ

For bimodal CI patients, the standard procedure for setting the level of the acoustic signal is to balance, in some fashion, the loudness relative to the CI signal. It is assumed that equal loudness of the two signals will produce the best results (e.g., Ching et al., 2004; Keilmann et al., 2009). We examine that assumption by presenting the acoustic signal at levels ranging from just over detection threshold to above the level of the CI signal and asking how performance varies as a function of the difference in level between the CI signal and the acoustic signal.

Five bimodal subjects participated in the project. The data suggest that (i) acoustic signals that are significantly softer than a CI signal can add to speech understanding with a CI, (ii) acoustic signals that are slightly softer than, or balanced with, a CI signal provide the largest benefit to speech understanding and (iii) acoustic signals presented at MCL provide nearly as much benefit as signals that have been balanced with a CI signal.

Poster #24 – CI10

Hearing Preservation Using the CI422 Electrode Array

Amy Olund, AuD; Douglas Sladen, PhD
Mayo Clinic, Rochester, MN

Background: Low frequency hearing preservation is commonly observed among cochlear implant (CI) recipients. Smaller electrode arrays and atraumatic surgical techniques are likely the major contributing factors. Preservation of low frequency hearing has been shown to improve speech perception in noise (Dorman et al 2012). Protecting intra-cochlear structures may increase post-operative speech understanding (Carlson et al. 2011). The current study investigates whether the newest straight slim electrode array (CI422) preserves hearing as well as recent perimodiolar electrodes arrays (CI24RE(CA) & CI512). Methods: This is an ongoing study. The experimental group consists, thus far, of 35 CI recipients with the 422 array. The control group was created by matching each 422 patient, according to preoperative audiometric thresholds at 125-1500 Hz, with a CI24RECA or CI512 CI recipient. Results: Once data collection is complete postoperative audiometric thresholds will undergo statistical analysis. Data analysis will determine if audiometric threshold differences exist between the two implant groups. Speech recognition data from the 3- and 6-month post-operative test interval will be analyzed. Conclusion: At the conclusion, this study will determine whether CI422 recipients appreciate more residual hearing than those who receive a perimodiolar electrode array. This study has direct implications for making critical clinical decisions.

Poster #25 – CI11 - **Mentored Student Research Poster Award**

Cochlear Implant Microphone Location Affects Speech Recognition in Diffuse Noise

Elizabeth Kolberg, BS (Mentored Student); Rene Gifford, PhD,
Vanderbilt University, Nashville, TN

OBJECTIVE: To investigate the effect of processor mic location on speech recognition in noise with various source azimuths.
DESIGN: Sentence recognition was assessed in noise with an 8-loudspeaker (R-SPACETM) array for 6 adult cochlear implant recipients. Speech was presented at 0^{o}, 90^{o}, or 270^{o} azimuth. Signal-to-noise ratio (SNR) was determined individually to achieve 50% correct in the unilateral implanted listening condition with speech at 0^{o}. Three microphone conditions were tested: T-Mic, 50/50 and integrated processor mic.
RESULTS: Results indicated a significant effect of sentence azimuth on speech recognition performance ($p< 0.001$). Best performance was achieved with the T-mic and the signal presented at 0^{o} azimuth. With the integrated processor mic, significantly higher performance was obtained with speech directed to the implanted side of the listener (+/- 90^{o}), rather than to the front (0^{o}).
CONCLUSION: Processor microphone location significantly affects speech recognition performance. Performance with the integrated BTE mic the standard mic location for most implant processors yielded significantly lower levels of performance when speech at 0^{o} azimuth. These findings have significant clinical implications such that implant recipients will perform best in diffuse noise using the T-mic setting. This finding has the potential to influence implant programming and future processor design.

Poster #26 – CI12 - **Mentored Student Research Poster Award**

Hearing Preservation Cochlear Implantation: Acoustic Bandwidth Required for Ipsilateral EAS
Kelly Jahn (Mentored Student); Sterling Sheffield, AuD; Rene Gifford, PhD,
Vanderbilt University, Nashville, TN

Objective: The primary aim was to determine the effect of acoustic bandwidth from preserved acoustic hearing in the implanted ear for benefit associated with electroacoustic stimulation (EAS).
Experiment: CNC word recognition was assessed for six implant recipients in quiet and in noise (+10 dB SNR). The following conditions were tested: 1) CI alone, 2) CI plus ipsilateral acoustic (ipsiEAS), 3) CI plus contralateral acoustic (bimodal) and 4) CI plus bilateral acoustic (EASall). Acoustic stimuli presented for conditions 2-4 were filtered as <125 Hz, <250 Hz, <500 Hz, <750 Hz, and unfiltered wideband.
Results: The pattern of EAS benefit was similar for bimodal and ipsiEAS conditions both in quiet and noise: significant benefit was observed with narrow bandwidths (125 or 250 Hz) and increasing benefit with bandwidth. No additional benefit was observed for acoustic hearing in the implanted ear beyond that associated with bimodal hearing.
Discussion: Results suggest that 1) CI recipients benefit from minimal acoustic hearing (125-250 Hz bandwidth) in either ear, 2) EAS benefit increases with aidable bandwidth, and 3) acoustic hearing in the CI ear provided no additional benefit over bimodal hearing for monosyllabic word recognition in quiet and in noise presented via direct connection.

Poster #27 – CI13 - **Mentored Student Research Poster Award**
Comparison of Vocoding Methods to Simulate Poor Electrode-Neuron Interfaces
Kelley Corcoran (Mentored Student), University of Washington, Seattle, WA
Leonid Litvak, PhD, Advanced Bionics, Valencia, WA
Julie Bierer, PhD, University of Washington, Seattle, WA

This study examined the performance of normal hearing listeners on vocoded speech perception to simulate the effect that a poor electrode-neuron interface might have in cochlear implant listeners. A poor interface could cause unwanted channel interaction or spectral smearing of speech signals. Speech stimuli were processed using a 16-band noise vocoder with 25 dB/octave filter slopes similar to the processing used in HiResolution (Advanced Bionics, Corp). Channels 6, 7 and 8 were selected to have a poor interface as they covered the frequency range of the second formant of most vowels. The four manipulations applied to degrade the three channels were; 1) no channel manipulation, 2) channel output set to zero replicating previous studies (e.g., Shannon 2002), 3) channel envelopes identical simulating complete channel interaction, and 4) channel envelopes averaged with random phase simulating a neural dead region. Speech perception was tested using ASU vowel and consonant identification, Consonant-Nucleus-Consonant words, and AZBio sentence recognition. The results with the averaged condition (4) were statistically poorer than the other conditions, and vowel performance was the most degraded. Preliminary conclusions suggest that a dead region is more detrimental than complete channel interaction, which might occur with an electrode distant from the target neurons.

DIAGNOSTIC AUDIOLOGY/OTOLOGY

Poster #28 – DX01
Effective Identification of Functional Hearing Loss
Robert Schlauch, PhD; Tess Koerner, University of Minnesota, Minneapolis, MN

Lynne Marshall, PhD, Groton, CT

Four protocols, designed to identify functional hearing loss using behavioral thresholds, were evaluated. For each protocol, 30 participants feigned a hearing loss first on an audiogram, and then for a screening test that began a threshold search from an extreme level (-10 or 90 dB HL). The noise-band protocol compared thresholds for an ascending noise band (0.5 - 1.5 kHz) to that for descending tones (0.5 and 1.0 kHz). The two-tone protocol and three-tone protocol compared thresholds for ascending and descending tones for two (0.5 and 1.0 kHz) and three (0.5, 1.0, and 2.0 kHz) frequencies, respectively. The spondee protocol compared an ascending spondee threshold to that for descending tones (0.5 kHz and 1.0 kHz). The screening test was then repeated without the participants feigning a loss. With cooperative participants, threshold differences between the ascending and descending screening tests were minimal for all protocols. When the participants feigned a loss, the spondee protocol produced the largest average threshold difference (30.7 dB) whereas the other protocols produced smaller differences (19.6-22.1 dB). With feigned losses, the spondee and three-tone protocols produced 100% true-positives and 0% false-positives when combined with the initial feigned audiogram.

Poster #29 – DX02

Auditory Function in WAGR Syndrome and Isolated Aniridia

Melissa Kokx, Gallaudet University, Washington, DC
Christopher Zalewksi, MA; Kelly King, PhD; Carmen Brewer, PhD, National Institute on Deafness and Other Communication Disorders, National Institutes of Health, Bethesda, MD
Amanda Huey; Shannon Fuhr; Kristen Danley; Melanie Hicks; Sheila Brady; Alyson Hanish, NICHD, NIH
Joan Han, MD, Unit on Metabolism and Neuroendocrinology, NICHD, NIH, Bethesda, MD

PAX6 encodes a transcriptional regulator of ocular and central nervous system development. Heterozygous PAX6 mutations cause isolated aniridia, while contiguous 11p13 gene deletions involving PAX6 and WT1 result in WAGR (Wilms tumor, aniridia, genitourinary anomalies, and mental retardation) syndrome. It has been previously reported that persons with PAX6 mutations may experience auditory interhemispheric impairments resulting in an auditory processing deficit (APD) (Bamiou 2004). We hypothesized that a similar auditory phenotype occurs in WAGR syndrome and that haploinsufficiency of other 11p13 genes may modify the severity of auditory deficits. We compared peripheral and central auditory function in 28 subjects with WAGR syndrome (age 6-28y) and 11 subjects with isolated aniridia (7-40y). Frequency of sensorineural hearing loss was similar for the WAGR and aniridia groups (4.5% vs. 9.1%, respectively, p=1.00 by Fisher's exact test). Frequency of auditory brain stem response abnormalities was also similar (50.0% in WAGR vs. 36.4% in aniridia, p=0.50). APDs were more frequent in WAGR (91.7%) compared with aniridia (36.4%, p=0.009). Our observations confirm that heterozygous PAX6 deletion is associated with auditory impairments. Further studies are needed to explore the contribution of intellectual disability and deletion of additional 11p13 genes to the higher prevalence of APDs in WAGR syndrome.

Poster #30 – DX03

Evaluation of Inter-Octave Frequency Thresholds: 1500, 3000, and 6000 Hz

Richard H. Wilson, PhD, VA Medical Center, Mountain Home, TN
Rachel McArdle, PhD, VA Health Care System, Bay Pines, FL

This study examined whether a 20-dB difference between thresholds at adjacent octave frequencies is the critical value for whether or not the inter-octave threshold should be measured and whether or not inter-octave thresholds can be predicted from the thresholds of the bounding octave frequencies instead of measured. Data for three inter-octave frequencies (1500, 3000, and 6000 Hz) from the left and right ears of a million participants were studied using primarily the median metric. Not all inter-octave thresholds were arithmetically between the bounding octave-frequency thresholds. As the inter-octave frequency increased from 1500 to 6000 Hz, the percent of thresholds at the inter-octave frequencies that were not equal to the median threshold increased from ~9.5% (1500 Hz) to 15.6% (3000 Hz) to 28.2% (6000 Hz). As the disparity between octave-frequency thresholds increased, the predictability of the inter-octave threshold decreased, e.g., using a ±5-dB criterion at 1500 Hz, 53% of the thresholds were ±5 dB when the octave thresholds differed by ≥20 dB, whereas 77% were ±5 dB when the octave thresholds differed by <20 dB. A 20-dB threshold difference between adjacent octaves is a good choice as the critical value in determining whether or not to test the inter-octave frequency.

Poster #31 – DX04

Air-Bone Gaps at 4 kHz in Sensorineural Hearing Loss

Samantha Ginter, BS; Robert Margolis, PhD, University of Minnesota, Minneapolis, MN
Christopher Bauch, PhD, Mayo Clinic, Rochester, MN
Robert Eikleboom, PhD, Ear Science Institute, Australia
Chad Johnson, AuD, University of Minnesota, Minneapolis, MN

Clinicians often observe 4-kHz air-bone gaps in normal-hearing subjects and subjects with sensorineural hearing loss who have normal middle-ear function on conventional audiologic tests. This finding motivated a search for data from published and unpublished studies to obtain the best estimate of the 4-kHz air-bone gap in normal and hearing-impaired subjects. Results from six studies from four laboratories will be presented. Methods included both automated and manual pure-tone audiometry and both mastoid and forehead bone conduction. Subjects were included if their air-bone gaps at 0.5, 1.0, and 2.0 kHz were < 5 dB. Air-bone gaps at 4 kHz for normal-hearing subjects from four studies ranged from -1.5 to 8.7 dB with a weighted mean of 7.1 dB. In subjects with sensorineural hearing loss 4-kHz air-bone gaps ranged from 10.8 to 17.4 dB with a weighted mean of 15.3 dB. The 4-kHz air-bone gap increases with the magnitude of the hearing loss, a finding that is not consistent with the traditional understanding of sensorineural hearing loss. The possibility that the 4-kHz air-bone gap is partially due to age-related changes in middle-ear transmission and partially due to an error in the standard bone-conduction calibration level at 4 kHz is being explored.

Poster #32 – DX05

Noise in Dentistry: Interference in the Hearing Health

Andrea Lopes, PhD; Maria Mondelli, PhD,
University of São Paulo, São Paulo, Brazil

In dental practice the dentist is subject to harmful effects caused by noise. Thus the aim of this study was to investigate the hearing threshold levels of dentists, dental auxiliaries and dental laboratory technicians. The study included 108 professionals divided into three different groups, all of them experimental groups: (G I) consisting of dentists, (G II) consisting of dental auxiliaries and (G III) consisting of dental laboratory technicians. The results showed that the mean hearing thresholds ranged from 5.68 dB to 21.59 dB for right ear and 3.64 at 23.07 dB for left ear; GII ranged from 5.42 dB

to 32.78 dB for right ear and 5.42 at 59.14 dB for left ear; G III ranged from 8.39 dB to 25.18 dB for right ear and 4.64 at 25.18 dB for left ear. The comparison between the mean hearing thresholds showed worsening with increasing the frequency. There was a statistically significant correlation between hearing threshold levels and the presence and/or absence of transient and distortion product otoacoustic emissions. The conventional audiometric assessment did not identify abnormal tests for the three groups tested.

ELECTROPHYSIOLOGIC RESPONSES

Poster #33 – ELECT01
Cochlear Microphonics in Infant High Level ABR Recordings
Carmen Condon, New York State Psychiatric Institute, New York, NY
Yvonne Sininger, PhD, UCLA, Los Angeles, CA
Tracy Thai; William Fifer, PhD, New York State Psychiatric Institute, New York, NY; in collaboration with the PASS Network

The cochlear microphonic (CM) component of ABR recordings has become an important part of the evaluation of pediatric patients especially for the differential diagnosis of auditory neuropathy spectrum disorder. Normative data on CM to high level stimuli in infants are not readily available. ABRs to 80 dB nHL click stimuli using both condensation and rarefaction stimuli are available on infants (newborn and 1 month of age) from the Prenatal Alcohol in SIDS and Stillbirth (PASS) study. The infants analyzed for the CM study have otherwise normal ABR to high level stimuli and present OAE and can be assumed to be free of auditory system impairment. The CM amplitude peaks around 1.2 to 1.3 ms following the click onset and the amplitude is within the same range as or slightly lower than the corresponding Wave 1. The duration of the CM is estimated by an assessment of cross correlation of condensation and rarefaction recordings in .5 ms segments. The correlations become positive at about the same time (latency) as Wave I is emerges, between 2 and 3 ms. Full statistical analysis on CM amplitude, latency and duration from at least 25 infants will be presented.

Poster #34 – ELECT02
The Acoustic Change Complex in Young Children with Hearing Loss
Amy Martinez, MA; Laurie Eisenberg, PhD, House Research Institute, Los Angeles, CA
Arthur Boothroyd, PhD, San Diego, CA

The study sought to determine whether the Acoustic Change Complex (ACC) can provide information on peripheral auditory resolution in young children with hearing loss. The ACC provides electrophysiological evidence of cortical response to change in an ongoing sound stimulus - indicating that there is the necessary peripheral resolution.
The ACC was recorded from five children with mild to moderately-severe hearing loss (27 to 75 months) and compared with responses from five children with normal hearing (31 to 56 months).
Stimuli consisted of sustained synthetic three-formant vowels that contained rapid alternation of the second formant between two values. In one stimulus the perceptual change was between /u/ and /a/ (a vowel-height contrast). In the other, it was between /u/ and /i/ (a vowel-place contrast).
With hearing aids activated, four of the five children with hearing loss produced observable P1 responses for both vowel contrasts at around 114 msec after the change, followed by a prolonged

negativity (N2) at around 230 msec. All of the children with normal hearing produced robust P1N2 responses.
These results provide evidence in support of the conclusion that the ACC can be used to assess the potential for phonetic contrast perception in young children with hearing loss.

Poster #35 – ELECT03 - **T35 Research Trainee Poster**
The Effects of Stimulus Level on ECAP Temporal Responses
Sarah Guillemette, BA, University of Northern Colorado, Denver, CO
Michelle Hughes, PhD, Boys Town National Research Hospital, Omaha, NE
Jacquelyn Baudhuin, AuD, Omaha, NE

Electrically evoked compound action potentials (ECAPs) have been used to examine temporal response patterns of the auditory nerve in cochlear implant (CI) recipients. Temporal response patterns have been shown to vary across stimulation rates. When slower rates are applied, an alternating ECAP amplitude pattern occurs, which represents the aggregate differences in relative refractory periods across individual nerve fibers. As stimulation rate increases, the alternating pattern may cease, reflecting desynchronization across fibers. The rate at which these alternations are no longer present has been termed the stochastic rate. Refractory-recovery time constants also change with stimulus level. The effect of stimulus current level on stochastic rate within subjects remains uninvestigated. The purpose of this study was to: (1) determine how stochastic rate changes as a function of stimulus level within subjects, and (2) to compare the changes in stochasticity to the changes observed in refractory-recovery time constants as a function of stimulus level. Stochastic rate and recovery time constants were determined for 9 ears of 7 subjects. Results showed faster stochastic rates and shorter refractory-recovery time constants for higher levels of stimulation within and across individuals. Understanding these patterns may provide further insight into the use of objective measures for optimizing speech processing strategies.

Poster #36 – ELECT04
ABR and Behavioral Off-frequency Masking Patterns
Julianne Ceruti; Frank Musiek, PhD,
University of Connecticut, Storrs, CT

Off-frequency masking (OFM) is the simultaneous masking of a signal by an off-frequency tone or noise. The purpose of this study, by using OFM, was a first step towards developing a method for measurement of electrophysiologic tuning curves employing ABR. OFM thresholds were established using psychophysical and ABR approaches for 2000 Hz tone bursts (2-0-2 cycles) at a repetition rate of 17.7 clicks per second. Four conditions consisted of an unmasked condition and three masked conditions with masking noise consisting of 1/3 octave band narrowband noise centered around 2000 Hz, 3000 Hz and 1500 Hz at 60 dB SPL. Threshold was measured by varying stimulus intensity while the masker remained stationary. In general, the shift due to masking was comparable between electrophysiological measures and psychophysical measures, with the average difference being about 10 dB. Contour of the psychophysical and electrophysiological tuning curves are similar, which corroborate results from Klein and Mills (1981), showing that it is possible to obtain reliable physiological tuning curves using waves I and V of the ABR in humans. Possible clinical applications are to provide an objective, ecological measure of frequency selectivity.

Poster #37 – ELECT05

Auditory Brainstem Responses to Clicks, Chirps, Tonebursts, and Octave-Band Chirps

Susan Stangl; Lindsey Rentmeester, AuD; Linda J. Hood, PhD,
Vanderbilt University, Nashville, TN

Chirp stimuli are designed to generate higher amplitude responses through improved neural synchrony. Frequency-specific chirps may offer advantages in applications where auditory brainstem responses (ABR) are used to estimate hearing sensitivity. The purpose of this study was to determine potential benefit of chirps over stimuli presently used in ABR testing. Specifically, we compared broad-band click and chirp stimuli, as well as tonebursts and octave-band chirps (Elberling et al., 2007) centered at four frequencies (0.5, 1, 2 and 4 kHz). Twenty young adult females with normal auditory function were tested with broad-band (100-microsecond clicks, CE-Chirps) and frequency-specific (tonebursts, octave-band chirps derived from the CE-Chirp) stimuli presented monaurally at intensities of 0-60 dB nHL. Behavioral and physiologic thresholds were obtained for all stimuli. Behavioral thresholds were comparable across stimulus types. Physiologic response thresholds were lower for chirp/octave-band chirp than click/toneburst stimuli with the greatest differences present at lower frequencies. ABR Wave V peak-to-peak amplitudes were greater for chirp/octave-band chirp stimuli; increased amplitudes varied with stimulus type and level. Broad-band and frequency-specific chirps show promise in increasing test efficiency and sensitivity by reducing test time through higher amplitude responses and providing more accurate response threshold estimation.

Poster #38 – ELECT06 - **Mentored Student Research Poster Award**

Auditory Brainstem Responses to Chirp and Click Stimuli in Newborns

Kensi Cobb (Mentored Student); Andrew Stuart, PhD,
East Carolina University, Greenville, NC.

Chirp stimuli maximize temporal synchronization of auditory nerve fiber responses by compensating for the traveling wave delay. This stimulus has been shown to produce auditory brainstem responses (ABRs) with significantly higher amplitudes relative to those with click stimuli in adults. Larger ABR amplitude waveforms to chirp stimuli are desired in both neuro-diagnostic and hearing screening with newborns. There are, however, currently no published studies that have examined the ABR to chirp stimuli in infants. The objective of this study is to compare ABRs to air- (AC) and bone-conducted (BC) chirp and click stimuli in healthy neonates. The effects of stimulus rate, and polarity, and intensity were manipulated: Three rates were examined with 60 dB nHL alternating AC stimuli (i.e., 77.7, 57.7, 8.7/s). AC condensation, rarefaction, and alternating polarities were examined at 60 dB nHL at rates of 8.7 and 77.7/s. Intensity effects were examined at 60, 45, and 30 dB nHL and 45, 30, and 15 dB nHL with 57.7/s alternating AC and BC stimuli, respectively. Preliminary data collection (n = 12) revealed longer wave latencies and larger amplitudes (with low and moderate intensities) with the chirp stimuli. Chirp stimuli may be feasible for hearing assessments with newborns.

Poster #39 – ELECT07

Speech-Evoked ABR: Periodicity Coding of a Temporally-Jittered Stimulus

Sara Mamo, AuD; John Grose, PhD,
University of North Carolina - Chapel Hill, Chapel Hill, NC

Reduced periodicity coding in the aging auditory system likely contributes to difficulty understanding speech in a noisy environment. There is a growing interest in characterizing such temporal deficits in older adults using speech-evoked auditory brainstem responses (sABR). Our laboratory has observed age-related changes in envelope coding using the sABR that may be due to reduced neural synchrony. This study tests a simulation of reduced neural synchrony designed to mimic, in normal-hearing young adults, the internal representation of the stimulus in older adults. The simulation involves imposing a random temporal jitter (Miranda and Pichora-Fuller, 2002) on the 170-ms /da/ stimulus used to evoke the sABR. The hypothesis is that perturbations of the stimulus periodicity will mimic neural temporal jitter, as reflected in reduced envelope coding of the speech stimulus. Response analyses focus on component amplitude for the sustained portion of the stimulus. To date, results show an amplitude reduction of the spectral components of the response for the jittered /da/ stimulus relative to the unprocessed /da/. These results suggest that disruptions to temporal periodicity of a complex stimulus can elicit a response pattern in young adults similar to that observed in the sABR spectrum in older adults. [NIH/NIDCD 1-F32-DC012217-01A1 & 5-R01-DC001507]

Poster #40 – ELECT08

Analysis of ASSRs and MLRs to 40Hz Silent Gaps

Khalid Alhussaini, BSc; Jorge Bohorquez, PhD; Ozcan Ozdamar, PhD,
University of Miami, Coral Gables, FL

Psychophysical detection of silent gaps embedded in ongoing steady sounds are commonly used to measure temporal resolution in hearing. Long latency auditory responses to gaps are routinely investigated as electrophysiological measures of temporal resolution. This study was conducted to investigate the characteristics of earlier responses (MLRs and ASSRs) to such stimuli. Young subjects were monaurally stimulated by silent 12 ms duration gaps (onset, offset: 1ms) embedded in low-pass filtered white noise (5Khz) at about 40 Hz rate. Equal and jittered inter gap intervals were employed to generate ASSRs and quasi-ASSRs (qASSRs), respectively. qASSRs were deconvolved using the CLAD (Continuous Loop Averaging Deconvolution) algorithm to obtain MLRs to individual gaps. Responses to conventional clicks were also recorded. All subjects detected the silent gaps and evoked well defined ASSRs and qASSRs but with smaller amplitudes compared to click responses. Spectral analysis of qASSRs showed greatly reduced magnitudes and lagging phases. Derived MLRs were characterized by two positive waves followed by smaller amplitude waves with no obvious relationship to conventional ABR and MLR peaks. Results suggest that gaps evoke responses in the brainstem/midbrain detectable by scalp recordings.

Poster #41 – ELECT09

Speakers Process Their Own Utterances Relative to the Preceding Utterance

Kevin Sitek, BA; Brian Roach; Daniel Mathalon, PhD; Judith Ford, PhD,
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Speakers respond differently to their own errant utterances compared to standard ones. Using electroencephalography, we collected event-related potentials (ERPs) from ninety-nine healthy subjects during self-produced speech and playback. While others have shown ERP changes due to experimentally altered feedback, we found ERP variability mirroring naturally produced speech variability. Previous work shows that the N1 ERP component is suppressed during self-produced speech compared to speech playback (Perez et al. 2011). In this study, research volunteers were asked to say [ah] at their own pace (usually every 1-2 seconds). Individual subjects' utterances were sorted based on

their first and second formant Euclidean distances from the previous utterance. By comparing ERPs to the least variable third of utterances vs. the most variable third of utterances, we found that N1 suppression during talking is significantly smaller following utterances that differ greatly from their immediately preceding neighbors, but not when utterances are sorted by deviance from the average of all utterances. This effect is driven by N1 differences in the talking condition's N1 during listening is not sensitive to deviance. These findings suggest that speaking induced suppression mechanisms are optimally tuned for a specific production, which is represented as the immediately preceding utterance.

Poster #42 – ELECT10 - **Mentored Student Research Poster Award**

Effect of Number of Epochs on Auditory Event-Related Potentials

Katharine Fitzharris, AuD (Mentored Student), University of Texas at Dallas, Dallas, TX
James Jerger, PhD, University of Texas at Dallas, Richardson, TX

One of the factors often cited in the reluctance of clinicians to adopt auditory event-related potential (AERPs) is the perception that they take too much time. In a typical AERP experimental procedure, the number of averaged epochs is governed by a number of factors (e.g., epoch length and the length of time it is reasonable to expect active participation). The question arises, however, whether results might be improved by averaging a larger number of epochs? The current study examined the effect of increasing the number of epochs on the processing negativity component (PNc; negativity over the range of 300-700ms) of AERPs under unforced- and forced-attention tasks. In 20 young adults, AERPs were collected to monosyllabic words presented both at the beginning and at the end of sentences. AERPs were analyzed after consecutive presentation of 40, 80, 120, and 160 trials; analysis was confined to the PNc of either the first or last word of each sentence. Two-factor repeated measures ANOVAs were used to evaluate differences in mean amplitude across the number of sweeps between experimental tasks. Preliminary results indicate that the greatest experimental effects on attention and semantic processing are attenuated rather than amplified by increasing the number of trials/epochs.

Poster #43 – ELECT11

Number of Background Talkers and Informational Masking Effects on CAEP

Kathy Vander Werff, PhD; Kaitlyn Coscione; J. Renee Cloutier,
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While continuous speech spectrum noise and multi-talker babble may offer similar amounts of energetic masking, babble is known to additionally provide challenges to speech understanding through informational masking. This study examines neural correlates of speech perception in noise at the cortical (obligatory) level using continuous speech-shaped noise and babble with varying numbers of talkers to better characterize the influence of informational masking. CAEPs were recorded in 18 normal-hearing young adults to a /ba/ syllable (300 ms, 65 dB SPL, binaural) at 14 channels at midline and over both hemispheres. Participants were tested in quiet and four noise conditions with equalized spectra (+10 and +0 SNR) presumed to represent most to least informational masking: 2-talker, 6-talker, 10-talker and continuous speech-shaped noise. Preliminary analyses showed that P1-N1-P2 waveforms for quiet and speech-shaped noise conditions were significantly different compared to all of the multi-talker babble conditions. Morphology of P1-N1-P2 waveforms was poorer as the number of talkers was reduced from 10 to 2. These results suggest that informational masking has an effect beyond energetic masking on the neural encoding of speech information even at the early stages of processing in the auditory cortex.

Poster #44 – ELECT12 - **Mentored Student Research Poster Award**
Onset-Offset N1-P2 Response Comparisons: A Possible Index for Tinnitus Verification
Jennifer Gonzalez, BA (Mentored Student); Frank Musiek, PhD,
University of Connecticut, Storrs, CT

The onset-offset N1-P2 auditory evoked response is an exogenous potential generated in the auditory cortex in response to long duration stimuli. In a sister study which examined onset-offset response changes resulting from stimulus alterations, 17 individuals were evaluated, three of which had chronic tinnitus (Gonzalez & Musiek, 2012). These three individuals exhibited notable morphological differences in their onset-offset responses compared to the 14 individuals without tinnitus. The present study is an extension of the aforementioned study. Two normal hearing subject samples were recruited, one with tinnitus and one without tinnitus. Broadband stimuli of 2000 milliseconds duration in 4500 millisecond gaps at 70 dB SL were presented to each subject binaurally and monaurally to each ear, and onset-offset N1-P2 responses were measured using the Neuroscan Stim2 system. Preliminary data from 5 non-tinnitus and 4 tinnitus individuals demonstrated amplitude differences between groups. A calculation using the differences in onset amplitudes and offset amplitudes as well as the differences in proportion of offset to onset amplitudes yielded indices that demonstrated a statistically significant difference between groups (P=0.038). These findings may reflect binaural processing differences in excitatory and inhibitory responses between groups using this monaural-binaural cortical evoked response paradigm.

Poster #45 – ELECT13
Electrophysiological Measures of Listening Effort
Scott Seeman, PhD; Rebecca Sims; Leslie Townsend,
Illinois State University, Normal, IL

Variability in cognition may explain why some individuals have greater difficulty hearing in noise. Subjective rating scales of listening effort are often used to quantify these differences in cognition. However, subjective ratings may not only reflect differences in listening effort but also reflect differences in criteria for defining effort. Alternatively, listening effort may be quantified with objective measures such as the dual-task paradigm or with objective electrophysiological measures. Mackersie & Cones (2011) suggested that skin conductance (SC) and frontalis electromyography (EMG) may be two effective measures of listening effort, at least for dichotic listening tasks. This study examines the use of three electrophysiological measures, SC, EMG and heart rate variability (HRV) to quantify listening effort for a speech in noise task in sixteen normal hearing young adults. Speech materials include fifteen Speech In Noise (SIN) test sentences at four signal-to-babble ratios of +15, +10, +5 & +0 dB. Results for these three electrophysiological responses will be discussed in context of performance and subjective ratings of listening effort.

HEARING LOSS AND REHABILITATION

Poster #46 – HLREH01
The Everyday Management of a Hard of Hearing Identity
Jessica West, BA, Massachusetts Eye and Ear Infirmary, Boston, MA

Sociological literature on hearing loss is currently limited to the effects that profound hearing losses have on individuals or to the effects that any kind of hearing loss has on children, adolescents, or adults. By applying the sociological concepts of stigma management, identity management, and emotional labor, this study addresses the gap in the literature through in-depth, qualitative interviews with twenty young people between the ages of 18 and 40 years of age with mild to moderate hearing loss. In exploring the everyday experiences of young, hard of hearing people, this study illustrates that managing a hard of hearing identity is hard work. From adjusting to the diagnosis to managing their hearing loss in everyday situations and interactions to their views of themselves and their futures, hard of hearing people constantly navigate conscious and unconscious decisions about their hearing loss.

Poster #47 – HLREH02

Do Hearing Aids Improve Quality of Life for Underprivileged Adults?

Jennifer Smart, PhD; Bridget Niedermeyer, Towson University, Towson, MD
Candace Robinson, AuD; Brian Kreisman, PhD, Grand Rapids, MI

The prevalence of hearing loss is estimated to be about 37 million people in the United States (Schoenborn & Heyman, 2008). It is well documented in the literature that hearing aids improve listening and quality of life (Carabellese et al., 1993; Garstecki & Erler, 1998; Harless & McConnell, 1982; Lotfi et al., 2009, etc.). Unfortunately, people with hearing loss living in underprivileged communities often don't have health insurance and/or access to audiological services. Even when audiology services are available the rising cost of amplification may make rehabilitation options limited. The main aim of this pilot study was to evaluate if hearing aids would improve the quality of life for the elderly living in a low socioeconomic status (SES) community. A case history, cognitive screening, the Hearing Handicap Inventory for the Elderly-Screener (HHIE-S), and a comprehensive diagnostic evaluation was performed. If their 4-frequency (.5, 1, 2, & 4 kHz) average was > 25 dB HL then they were fitted with bilateral digital hearing aids donated from two hearing aid companies. A follow-up appointment was conducted and the HHIE-S was administered again. Results from this study will be discussed along with suggestions for future audiology programs in low SES communities.

Poster #48 – HLREH03

Hearing Loss, Hearing Handicap and Subjective Fatigue

Benjamin Hornsby, PhD; Aaron Kipp, PhD,
Vanderbilt University Medical Center, Nashville, TN

The negative effects of hearing loss on communication and psychosocial function are significant and well documented (Arlinger, 2003). In general, negative psychosocial effects increase with degree of hearing loss (Weinstein and Ventry, 1983). Fatigue is a common, but often overlooked, accompaniment of hearing loss that also negatively affects quality of life. However, empirical research examining relationships between hearing loss and fatigue are limited. In this study we examine relationships between audiometric factors (e.g., degree of loss) and the subjective percepts of fatigue and vigor. Relationships between fatigue, vigor and the social and emotional consequences of hearing loss are also explored. Fatigue and vigor were assessed using the Profile of Mood States (POMS; McNair et al., 1971) and the Multidimensional Fatigue Symptom Inventory-short form (MFSI-SF; Stein, et al., 2004). To assess the social and emotional impact of hearing loss participants also completed, depending on their age, the Hearing Handicap Inventory for the elderly (HHIE; Ventry and Weinstein, 1982) or adults (HHIA;

Newman et al., 1990). Data from 150 adults scheduled for hearing testing at the Vanderbilt Bill Wilkerson Center were collected and will be used to explore relationships between audiometric and demographic (i.e., age and gender) factors, fatigue and hearing handicap.

Poster #49 – HLREH04
Investigation of the Optimal Dose and Duration for Auditory Training
Dana Kinney, MA; Sara Brown, AuD; Annie Kiener, AuD; Larry Humes, PhD,
Indiana University, Bloomington, IN

We have previously demonstrated the efficacy of an auditory-training system that makes use of frequently occurring words and has been designed for use by older adults with impaired hearing. Remaining questions to be addressed for this training system include the optimal duration and frequency (dosage) of training. These questions were addressed in this study. A group of 60 older (61-79 years) hearing-impaired listeners were randomly assigned to one of three groups: (1) a passive control group (N=22); (2) a 2x/week training group (N=17); and (3) a 3x/week training group (N=21). For each group, a pre-training/post-training within-subject design was used with post-training evaluations completed after 1, 2, and 3 cycles of training. For the control and 3x/week groups, a training cycle was 5 weeks in duration, and for the 2x/week group, a training cycle was 7.5 weeks in duration. There were no significant group differences in pre-training aided speech-recognition performance. In addition, there were no significant group differences in post-training aided performance between the two trained groups. Both trained groups, however, performed significantly better than the control group on all trained measures. In most cases, training benefits reached asymptote after 1 training cycle. (Work supported, in part, by NIDCD R01-DC010135-01).

HEARING SCIENCE AND PSYCHOACOUSTICS

Poster #50 – HSPSY01
Sensitivity of Eardrum Pressure to Placement of Circumaural Headphones
Kathleen Dunckley, MA; Jonathan Siegel, PhD,
Northwestern University, Evanston, IL

Circumaural headphones are routinely used in laboratory and clinical settings to make psychoacoustic measurements at frequencies greater than 8 kHz in human ears. Current calibration standards specify use of a flat-plate coupler (IEC 318), which does not account for pinna effects that exist within the headphone field in a real-life measurement. Transfer functions in response to chirps were made with circumaural headphones (Sennheiser HD265 and HDA200) coupled to a dB100 ear simulator (ANSI/ASA S3.25-2009) either using a modified flat-plate or a standard Kemar external pinna (RA0143). Serial measurements by multiple testers were recorded while positioning the headphone over the center, or deliberate placement at the extremes of possible positions on the coupler apparatus. Variability was greatest for the HD265 for randomly paired measurements made across testers in the pinna condition, greater than 10 and 20 dB level difference at 10 and16 kHz, respectively. Variability was smallest for a single tester in the flat-plate condition for the HDA200. Although the HD265 has sufficient high frequency bandwidth, it was not engineered to be as insensitive to headphone placement as the HDA200, which makes the HDA200 the preferred choice for level dependent psychacoustic measures.

Poster #51 – HSPSY02 – Abstract Withdrawn

Poster #52 – HSPSY03 - **T35 Research Trainee Poster**
Hair Cell Ablation using Pou4f3-DTR Transgenic Mice
Darius Zamani; Keiko Hirose, MD; Mark Warchol, PhD,
Washington University School of Medicine, St. Louis, MO

A model system was created in which hair cells are strategically eliminated by placing the gene for diphtheria toxin receptor (normally absent in mice) under the control of the Pou4f3 promoter (Tong, Hume, Palmiter & Rubel, 2011). This promoter is exclusively expressed in inner and outer hair cells which are selectively targeted by systemic injection with diphtheria toxin. Electrophysiologic testing and histologic analysis of the inner ears of these mice as well as a characterization of the inflammatory response in this model are described here. Distortion product otoacoustic emissions and auditory brainstem response thresholds were consistent with profound hearing loss. Plastic embedded cochlear sections showed total ablation of hair cells throughout the entire frequency range. Immunohistochemistry with myosin VIIa displayed degeneration of inner and outer hair cells which appeared to invoke a remarkable inflammatory response, despite the lack of disruption of the sensory epithelium outside of specific loss of hair cells. Macrophages quantification showed a robust increase in numbers of inflammatory cells through the cochlea, and particularly in the scala tympani.

Poster #53 – HSPSY04 - **T35 Research Trainee Poster**
Monitoring Middle Ear Status in C57BL/6J Mice Using Wideband Absorbance
Laura Horowitz, BA; Brian Faddis, PhD, Washington University School of Medicine, St. Louis, MO
Wafaa Kaf, MD, Springfield, MO

Wideband absorbance with pressurization (WBA) was measured in a mouse model of chronic otitis media (OM). OM was induced in 10 C57BL/6J mice via intranasal inoculation with Bordetella hinzii and monitored for one month. Animals were then treated with antibiotics for to affect recovery. Progressive changes in middle ear status were monitored with WBA and distortion product otoacoustic emissions (DPOAEs). Five mice were sacrificed prior to recovery and five following antibiotic treatment. Horizontal whole head sections were prepared to examine the middle ear and surrounding structures for signs of infection. Results of the DPOAE testing revealed a slight to complete reduction of emission amplitudes in seven of ten animals one month post-inoculation and a partial to complete recovery of levels following one month of antibiotic treatment. Two regions of interest were identified on WBA profiles, a high frequency 'peak' and a low-frequency 'ridge'. Analysis suggested the low-frequency ridge more accurately reflects the course of infection and recovery than the high-frequency 'peak.' Histological preparations revealed ossicular bone remodeling and minor inflammatory infiltrate in several of the animals following antibiotic treatment. The findings of this study suggest WBA profiles may provide a useful, non-invasive measure of middle ear status in the mouse.

Poster #54 – HSPSY05 - **T35 Research Trainee Poster**
Effects of Exposure to Unilateral Versus Bilateral Noise in Mice
Kevin Ohlemiller, PhD, Washington University School of Medicine, St. Louis, MO
Jeffrey Cooper, A.T. Still University, Mesa, AZ

Background: Some experiments and assessment methods utilize unilateral noise exposure (NE). It is possible, however, that unilateral and bilateral NE yield different results, perhaps by differentially engaging middle ear reflexes or efferent activity. We tested whether unilateral and bilateral NE yield the same noise-induced permanent threshold shifts (NIPTS) in CBA/J mice.
Methods: Baseline Auditory Brainstem Response (ABR) tests were administered to 16 subjects (8 male, 8 female) ranging 9-10 months in age, binaurally. Left ears (LEs) of 8 mice were plugged using a custom ear plug and adhesive. All mice were then exposed to 2 hours of 8-16 kHz octave band noise at 110 dB SPL 24 hours later. Plugs were then removed and two weeks later binaural ABRs obtained from all mice to determine effectiveness of LE plug and to test for differences among exposed right ears (REs) when the LE was plugged versus unplugged.
Results: Plugging the LE resulted in a reversible conductive hearing loss and showed no NIPTS on average. REs showed statistically similar NIPTS regardless of whether the LE was plugged or unplugged.
Conclusion: At least for a single intense NE, we find no evidence of interaction between the two ears in CBA/J mice during NE.

Poster #55 – HSPSY06
Effects of Masker Envelope Fluctuations and Temporal Uncertainties on Overshoot
Scott Seeman, PhD, Illinois State University, Normal, IL
Harisadhan Patra, PhD, Bloomsburg University, Bloomsburg, IL

Overshoot refers to an increase in detection thresholds for a short-duration signal if presented at or near the onset of a masker instead of with a long onset delay. Although research suggests that overshoot may be related to cochlear active processes, neural adaptation, and central processes; its mechanisms remain unclear. This study was designed to investigate the effects of masker-envelope fluctuations and temporal uncertainties on overshoot. Signals were 10 ms long 2500 and 5000 Hz sinusoids. Maskers were 350 ms long, half-octave wide low-noise noise and random-phase noise. The maskers were centered one-half octave above or below the signal frequencies. The inter-onset delays were either fixed at 0, 4, 170, 325, and 340 ms or randomly varied from trial to trial. The masker levels were 30, 50, and 70 dB SPL. Effects of masker envelope fluctuations and temporal uncertainties on overshoot will be discussed. [Supported by BURSG].

Poster #56 – HSPSY07
Effects of Sensorineural Hearing Loss on Roving-Level Tone-in-Noise Detection
Junwen Mao, MS, University of Rochester, Rochester, NY
Karen Doherty, PhD, Syracuse University, Syracuse, NY
Kelly-jo Koch; Laurel Carney, PhD, University of Rochester, Rochester, NY

Studies of detection of tones in reproducible noises showed that listeners with normal hearing use an optimal combination of energy, temporal envelope and fine-structure cues for diotic detection (Mao et al., JASA 129:2489). However, listeners with mild to moderate sensorineural hearing loss (SNHL) use only energy and/or envelope cues, with no evidence that these cues are combined. Because envelope and energy cues are correlated, it is difficult to tease apart their contributions in a fixed-level task. One way to evaluate these cues separately is to rove the level, making the energy cue unreliable while not affecting the envelope cue. It was hypothesized that, if the envelope cue dominated, listeners' thresholds and detection patterns (hit and false-alarm rates) would not be affected by roving levels.

Listeners with SNHL were tested with a 20-dB rove range, and results were compared to those from previous fixed-level conditions for both narrowband and wideband diotic conditions. Tone-in-noise detection thresholds did not differ significantly between fixed-level and roving-level conditions. Additionally, detection patterns for noise samples were highly correlated to those from fixed-level conditions. It was concluded that the envelope cue dominated diotic tone-in-noise detection for listeners with SNHL. Implications for hearing-aid signal processing will be discussed.

Poster #57 – HSPSY08 - **T35 Research Trainee Poster**
Nonadditivity of Forward and Simultaneous Masking
Adam Svec, MA, University of Minnesota, Minneapolis, MN
Suyash Joshi; Walt Jesteadt, PhD, Boys Town National Research Hospital, Omaha, NE

The current study measured the additional masking obtained for combinations of forward and simultaneous maskers as a function of forward masker (FM) bandwidth, signal delay, and simultaneous masker level. The effects of the two individual maskers were equated in all conditions. Additional masking increased as a function of increased masker level, increased signal delay, and decreased masker bandwidth. The masker interactions influencing additional masking occurred at the time of the signal, not during the forward masker. The difference in additional masking observed as a function of forward masker bandwidth and the interaction between the effects of forward and simultaneous maskers call into question the use of additional masking as a measure of basilar membrane compression and present problems for the use of simultaneous noise to simulate hearing loss.

Poster #58 – HSPSY09
A New Method to Quantify Horizontal Localization Performance
Jingjing Xu, PhD; Robyn Cox, PhD
University of Memphis, Memphis, TN

Horizontal sound localization performance is often descriptively displayed by plotting presentation azimuths against response azimuths. With this descriptive method, error patterns are difficult to interpret and difficult to compare across listening conditions. The purpose of this poster is to introduce a new method for quantifying horizontal localization performance which facilitates descriptive comparison across listening conditions. With the new method, localization performance is quantified using Area of Angular Error (AAE), which is the area of the polygon formed by connecting the mean absolute angular errors for adjacent azimuths on a polar plot. Descriptively, performance is quantified using a visual representation of the polar pattern. Using the AAE method, the difference in the pattern of localization errors between two conditions, such as two hearing aids, is readily visualized. The validity of the AAE method was assessed by comparing it with the traditional approach using RMS error across azimuths. Statistically, the two methods produced the same results. The descriptive advantage of the AAE method will be demonstrated and the advantages of each approach will be presented. The AAE method is especially useful for comparing different hearing aid technologies. (Supported by NIDCD)

Poster #59 – HSPSY10
Relative Loudness of High-Pass Filtered Speech During Speech Production
Dragana Barac-Cikoja, PhD; Monica Majewski,, Gallaudet University, Washington, DC
Claire Morgan; Whitney Kidd

During speech production, the level of speech input at low frequencies is significantly increased by the presence of bone conducted feedback. We investigated speakers' perception of own voice relative loudness in two conditions, when the speech signal was (1) high-pass filtered (cutoff frequency = 800 Hz) and (2) unaltered. The subject's speech was recorded with a microphone placed above his/her right ear, and presented binaurally via insert earphones. An adaptive, two-track, two interval forced choice procedure was used. The subject indicated which of two signals, the live speech (listening while speaking interval) or its replay (listening only interval) sounded louder. Relative loudness of the speech feedback was measured by the difference in the sound pressure level (SPL) of each signal (live and replay), when the two were experienced as equally loud. Five normally hearing adults completed the test. At the point of subjective equality, for the unaltered speech, the SPL of the live speech exceeded the SPL of the replay for most subjects (N=4). For the filtered speech, the difference in SPL was either significantly reduced or inverted for all but one subject. The role of peripheral attenuation mechanisms during speech production will be discussed.

HEARING TECHNOLOGY/AMPLIFICATION

Poster #60 – AMP01

Aided Speech Recognition in Noise for Children with Hearing Loss

Ryan McCreery, PhD, Boys Town National Research Hospital, Omaha, NE
Elizabeth Walker, PhD, University of Iowa, Iowa City, IA
Meredith Spratford, AuD, Boys Town National Research Hospital, Omaha, NE
Shana Jacobs, AuD, University of North Carolina, Chapel Hill, NC
Ellen Hatala, Boys Town National Research Hospital, Omaha, NE

Amplification is provided to children with hearing loss in order to make speech audible. While aided audibility has been shown to predict children's speech recognition in quiet, significant variability in performance is observed in noise even after audibility is improved with amplification. This suggests that additional factors may impact speech understanding in children with hearing loss, particularly in noisy environments. The purpose of the current study was to evaluate the effect of hearing aid use time, aided audibility, and speech and language abilities on a word recognition task in noise for a group of 33 children between 4 and 9 years of age with mild to severe permanent hearing loss. Word recognition was measured at three signal-to-noise ratios using the Computer Assisted Speech Perception Assessment (CASPA). Receptive vocabulary was measured using the Peabody Picture Vocabulary Test - 4, speech production was measured using the Goldman-Fristoe Test of Articulation and hearing aid use time was measured using data logging from the hearing aids and parent report. Results indicate that aided audibility, hearing aid use time, and receptive vocabulary predicted aided speech recognition in noise. Implications for optimizing amplification for children with hearing loss will be presented.

Poster #61 – AMP02

The Situational Hearing Aid Response Profile: An Update

Marc Brennan, PhD; Ryan McCreery, PhD; Dawna Lewis, PhD; Thomas Creutz; Patricia Stelmachowicz, PhD
Boys Town National Research Hospital, Omaha, NE

Infants and children listen to speech at many input levels that may not be assessed using typical verification methods. The Situational Hearing Aid Response Profile (SHARP) lets clinicians assess audibility across a variety of speech input levels (e.g. cradle position, classroom). SHARP is useful for comparing the impact of different electroacoustic characteristics of hearing aids on audibility in these environments. Previous versions required users to manually input electroacoustic characteristics of the hearing aid into the program. Also, those versions did not account for recent advances in hearing-aid technology. This poster describes modifications to SHARP that allow users to import electroacoustic data and updated methods to predict outputs for multiple speech inputs. Measurements of the accuracy of those predictions were assessed. Ten hearing aids were set to DSL-child for soft, average, and loud speech for three simulated audiograms. The electroacoustic data were imported into the program. A linear regression predicted output for different speech inputs. The accuracy of those predictions was compared to actual measurements. Preliminary data suggest that SHARP predicts to within 5 dB of measured output. This update to SHARP allows users to easily and accurately determine audibility across speech inputs.

Poster #62 – AMP03

Audible Hearing Aid Bandwidth When Measured with a Speech Stimulus

Chelsea Blom, University of Nebraska – Lincoln, Lincoln, NE
Dawna Lewis, PhD; Ryan McCreery, PhD, Boys Town National Research Hospital, Omaha, NE

Hearing aid bandwidth has been linked with improvements in perception and sound quality for listeners with hearing loss. Few studies have reported on the bandwidth of wearable hearing aids or remote-microphone hearing assistance technology (HAT) systems using a realistic speech stimulus and various degrees of hearing. The upper frequency limits of eight behind-the-ear hearing aids with a range of bandwidths were examined using a realistic speech stimulus and three different audiometric configurations through a KEMAR manikin. The International Speech Tests Signal (ISTS), broadband noise, and an isolated /asa/ were presented through a loudspeaker to KEMAR positioned at 0° azimuth. The maximum audible frequency for each hearing aid, each audiogram, and each stimulus was obtained using visual inspection. The audible bandwidth was also determined for five different HAT scenarios. The maximum audible frequency varied significantly across devices and degree of hearing loss and the estimated bandwidth from ANSI was not predictive of the audible bandwidth across conditions. In some cases, the HAT system had a more limited bandwidth than the hearing aid. Clinicians can easily estimate the audible bandwidth as part of the hearing aid verification process to assist in decisions about devices, signal processing, and hearing assistance technology.

Poster #63 – AMP04

Clinical Validation of a New Combination Device for Tinnitus Treatment

Elizabeth Galster, AuD; Harvey Abrams, PhD; Michelle Hicks, PhD,
Starkey Hearing Technologies, Eden Prairie, MN

Sound therapy, or use of any sound for the purposes of tinnitus management, is widely accepted as a management tool for tinnitus. Combination devices, or devices that incorporate both hearing aid and sound generator functionalities, are commonly used as a part of a sound therapy program. A new combination device incorporating a frequency and amplitude modulated stimulus and a user-interface for patient adjustment of the stimulus during a fitting session was evaluated in a field trial. The primary purpose of this investigation was to evaluate the effectiveness of this device for management of

tinnitus. Participants wore the devices for an 8-week field trial, and completed both the Tinnitus Handicap Inventory and the Tinnitus Functional Index at the beginning and end of the field trial. Results indicated statistically significant improvement in tinnitus handicap and severity as indicated by both standardized questionnaires. Eleven of 19 participants reported benefit from the devices and exhibited a clinically significant improvement on at least one questionnaire by the end of the study. An additional four participants reported benefit, but did not exhibit a clinically significant change in questionnaire scores at the end of the 8-week field trial. Patient feedback revealed variability in preferences for stimulus settings.

Poster #64 – AMP05

Application of the Expectancy-Disconfirmation Model to Predict Hearing Aid Satisfaction

Elaine Mormer, MA; Catherine Palmer, PhD, University of Pittsburgh, Pittsburgh, PA
Jeffrey Inman, PhD, Pittsburgh, PA
Sheila Pratt, PhD; J. Scott Yaruss, PhD, University of Pittsburgh, Pittsburgh, PA

Hearing aid use is associated with improved quality of life for people with hearing loss. Despite significant technological advances, hearing aid market penetration has remained relatively low over the last three decades. Studies exploring hearing aid satisfaction have not consistently revealed the most salient contributing factors. The expectancy-disconfirmation model of satisfaction proposes that the size of difference between a consumer's expectation and perception of a product (disconfirmation) is predictive of satisfaction. This model has been empirically tested in health care contexts like vision correction, hospitalization, and pharmacy purchases and in consumer services and purchases. A study of the expectancy-disconfirmation model, conducted in Hong Kong, suggested disconfirmation might contribute to satisfaction in Chinese first-time hearing aid users.
Survey data on hearing aid disconfirmation, perceived performance, and hearing aid satisfaction were collected to operationalize the constructs of the expectancy-disconfirmation model. Data from 68 hearing aid purchasers was analyzed using regression modeling. Results suggest disconfirmation accounts for a significant portion of variance in satisfaction. This study elucidates the role of expectations in hearing aid satisfaction. It provides the first empirical evidence that the expectancy-disconfirmation model can be applied to further study of satisfaction in first time hearing aid purchasers in the United States.

Poster #65 – AMP06

Is Normal Loudness the Appropriate Goal for Hearing Aid Fittings?

Jani Johnson, AuD, PhD; Robyn Cox, PhD,
University of Memphis, Memphis, TN

Current generic hearing aid prescriptions aim to restore loudness perception to levels close to those experienced by normal-hearing listeners. However, when adjustments based on individual preferences are applied, modifications of gain-frequency responses can result in fittings with loudness characteristics that are considerably removed from the original goals. In this research, we ask whether loudness normalization is the goal desired by hearing aid users. A total of 60 bilateral hearing aid fittings were accomplished for adults with mild to moderate sensorineural hearing loss. For each fitting a four-step procedure with high face validity was implemented: 1) NAL-NL1 target-matching; 2) structured subjective verification; 3) one-week follow-up fine-tuning; and, 4) individual modification of gain settings over a one month field-trial. After the trial, participants indicated their perceptions of soft, average, and

loud environmental sounds using the Profile of Aided Loudness (PAL). Data were compared to PAL norms. Results indicate that when hearing aid fittings are carefully adjusted using best-practice methods, loudness is more than normal for soft sounds, equal to normal for average sounds, and below normal for loud sounds. These data, and other published work, suggest that loudness goals should be modified. (Supported by NIDCD)

Poster #66 – AMP07

User Evaluation of a Hearing Instrument System for Noisy Conditions

Peggy Nelson, PhD; Michael Sullivan, AuD, University of Minnesota, Minneapolis, MN
Chris Conger, MS; Yingjiu Nie, PhD

It is reported that approximately 10% of people with mild hearing loss and 26% of people with moderate hearing loss have adopted hearing aids (Kochkin, hearingreview.com, 2009). People with mild to moderate hearing loss experience difficulties understanding speech in noisy environments. A hearing instrument system was designed and produced by IntriCon to facilitate these listeners' speech understanding in challenging environments. The Lumen 1000 system consists of a pre-programmed amplification device with a slight high-frequency gain acting as a receiver for radio frequency signals via a pre-paired transmitter. Transmitters included a companion microphone (voiceStream) and an audio-adaptor (linkStream). Listeners with mild to moderate hearing loss used a Lumen system for a one-week trial period in three environments in restaurants, when driving or riding a car, and when watching TV. A quick-start guide was provided along with the system, but participants received limited instructions from the audiologist. A subjective report was completed for preferences, ease of operating the system, and any issues or concerns. Preliminary observations show positive responses to the system. The responses of the users will be correlated with their age, comfort with technology, and hearing loss. [Project supported by IntriCon Corp.]

Poster #67 – AMP08

Horizontal Localization with Pinna-Shadow Compensation Algorithm and Inter-Ear Coordinated Compression

Petri Korhonen, MS, Widex, Chicago, IL

This study examined the localization performance of hearing impaired listeners in the horizontal plane when using a behind-the-ear (BTE) hearing aid incorporating a pinna-shadow compensation algorithm and coordinated inter-ear compression. Fifteen experienced hearing aid users with bilateral sensorineural hearing loss participated. The participants were provided with a regimen of computerized take-home and in-laboratory localization training. Localization performance was measured in quiet using a 12-loudspeaker array evenly distributed on a horizontal plane. The performance was reported using the 'Center of Mass' (CoM) method, which considers the proportion, direction, and size of localization errors simultaneously. This analysis method takes account for the circular nature (on a 360° scale) of the responses, and allows multivariate analyses of variance (MANOVAs) for the entire dataset on trial-by-trial basis. The data demonstrated that the use of pinna-shadow compensation algorithm improved the localization accuracy over a BTE hearing aid with an omnidirectional microphone. The back localization errors were reduced on average by 22% for broadband sounds and 29% for high-pass filtered sounds. The use of coordinated inter-ear compression showed on average no significant effect in localization performance. However, a modest improvement in localization performance was measured for some listeners.

Poster #68 – AMP09

Evaluating Pre-fitting Measures for Hearing Aid Selection

Brittany Tennyson, BA, BS; Rachel Van Oosbree, BS; Kelly Van De Wyngaerde; Thomas Muller, AuD; Nicole Marrone, PhD, University of Arizona, Tucson, AZ

One goal of hearing aid selection is to optimize listening across multiple acoustic environments. However, outcomes can be variable and unpredictable, especially for aided listening in noisy, cognitively demanding situations. This study addresses whether pre-fitting measures of speech recognition in noise would better inform the clinician's selection of hearing aid features. For example, there are multiple ways to implement directional processing within hearing aids; however, there is not an evidence-based way to navigate the decision-tree of options. The hypothesis tested here is that a given listener's resilience or susceptibility to the effects of multiple competing sources may contribute to whether or not directional benefits are realized in real-world settings. Adults with bilateral, symmetric mild to moderate sensorineural hearing loss were tested under omnidirectional and directional microphone configurations using commercially available hearing aids. Each listener completed a battery of pre-fitting tests in the unaided condition. Subsequent aided testing was performed using the Coordinate Response Measure stimuli in co-located and spatially separated conditions at signal-to-noise ratios representative of common listening environments in daily life. Pilot results indicate substantial inter-listener variability across different environments. Discussion will address the utility of speech-in-noise recognition as a pre-fitting measure.

Poster #69 – AMP10

Development of a Subjective Measure of Listening Effort

Rachel Van Oosbree, BS; Brittany Tennyson, BS; Holden Sanders; Thomas Muller, AuD; Nicole Marrone, PhD, University of Arizona, Tucson, AZ

Directional processing is a commonly recommended, evidence-based choice for improving signal-to-noise ratio when listening with hearing aids in complex environments. However, there is a discrepancy reported in the literature between the amount of improvement expected and the amount that may be realized by the individual patient. That is, listeners may report more or less benefit from directionality in their day-to-day lives than would be predicted based on objective laboratory tests depending in part on the characteristics of their listening environment. Here we report on a subjective questionnaire to capture differences in contributors to listening effort corresponding to changes in directionality and listening environment. This research fits into a larger program of study on pre-fitting procedures that could be used systematically during the hearing aid selection process to match device features to an individual's needs on the basis of what best predicts success in everyday listening. Our hypothesis is that the individual's self-perception of communication is determined by an interaction between the limits of the individual's speech recognition performance and the characteristics of the listening environment. We find that even when performance is at a ceiling or a floor, subjective questions may be sensitive to changes in the listening environment.

Poster #70 – AMP11

Speech Perception and Quality of Life in Open Fit Users

Maria Fernanda Mondelli, PhD; Andrea Lopes, PhD; Tatiana Garcia, MD,

Bauru School of Dentistry - University of Sao Paulo, Bauru, Brazil

Individuals with descending hearing loss report difficulties in speech perception in noise, leading to social withdrawal and may decisively affect the quality of life. Objective: To assess the relationship between speech perception and quality of life and if there is an improvement in the quality of life after the adaptation of hearing aids. Materials and Methods: We evaluated 30 patients by means of the HINT (Hearing in Noise Test) and the quality of life with the questionnaire WHOQOL-Breef (World Health Organization Quality of Life) at the day of the adaptation and 30 days after it. Results: There was a relationship between the results of the Composite HINT and the quality of life. There was no relationship between Quiet HINT and the quality of life. There was no significant improvement in the quality of life after the fitting of hearing aids, when analyzing the results of each individual separately. However, when analyzing the group as a whole, an improvement in the quality of life in general was noticed. Conclusion: Subjects with better speech perception in noise have a better quality of life. The fitting of hearing aids during the acclimatization period still does not present significant improvements in the quality of life of the individual.

Poster #71 – AMP12

Performance in Speech Recognition Using Directional Microphone

Maria Fernanda Mondelli, PhD; Andrea Lopes, PhD; Monica França, MD; Caio Almeida,
Bauru School of Dentistry - University of Sao Paulo, Bauru, Brazil

Recent technological advances have enabled an improvement of strategies for signal processing in hearing aids (HA), providing better performance in speech comprehension. Currently, directional microphones can be used to offer different sensitivity according to the angle of incidence of the sound wave. This study aims to investigate speech recognition perfomance in noise for hearing impaired adults using a hearing aid with a directional microphone, comparing with other two situations: without HA and with HA and omnidirectional microphone. Material and Methods: A cross-sectional study with 15 subjects bilaterally fitted with digital hearing aids was performed. Each subject was evaluated by the HINT - Brazil test in three conditions: without HA, with HA and omnidirectional microphone activated, and with HA and directional microphone activated. Results: Through analysis of descriptive measures and statistical tests (Friedman ANOVA and Wilcoxon) we have been able to verify that directional microphone is significantly better compared to the other situations. Conclusion: Based on the results, it's possible to conclude that the directional microphone contributes most significantly to speech recognition in noise.

Poster #72 – AMP13

Amplification and the Effort Associated with Speech Recognition in Noise

Jean-Pierre Gagne, PhD, University of Montreal, Montreal, Quebec, Canada

A dual task paradigm was used to compare the effect of monaural vs. binaural amplification on the effort (attentional/cognitive resources) required to recognize speech in noise. Five adults with hearing loss who used binaural amplification took part in the investigation. For each participant, comparisons were conducted under three listening conditions: (1) binaural amplification, (2) monaural amplification at the same SNR than for the binaural condition, and (3) monaural amplification at an adjusted noise level in order to yield the same level of performance on the speech task as in the binaural condition. There were three experimental tasks: (1) A primary task which consisted of a sentence-recognition task

in noise; (2) a secondary task which consisted of a 2-element tactile pattern recognition task; and, (3) a dual task condition which consisted of the primary and the secondary task being administered concurrently. Effort was measured: (1) as a decrement in performance on either tasks when it was administered under the dual-task condition, and (2) longer response-time under the dual-task condition, relative to the single task conditions. The results of this pilot investigation indicate that speech understanding in noise is more effortful when it is performed under a monaural condition.

Poster #73 – AMP14

Using Spectrograms to Visualize Frequency Lowering Systems in Hearing Aids

Barbara Simon, AuD, Martin Kuriger, Bernafon AG, Bern, Armed Forces Africa
Neil Hockley; Christophe Lesimple; Julie Tantau, AuD, Bernafon AG

Frequency lowering techniques are a way to improve the ability of the hearing impaired individual to obtain benefits from speech cues that would otherwise be distorted or even imperceptible using traditional amplification. In order to verify these new techniques, there needs to be methods to assess what they do either in situ or in a test box. For example, the Verifit REM system has a test signal where, for each stimulus, the 1/3 octave band levels above 1000Hz are reduced by 30dB, except for an isolated 1/3 octave band centered at the frequency indicated e.g. 4000Hz. This allows testing of a frequency lowering system at specific target frequencies. Is there, however, another way that frequency lowering systems can be examined without using dedicated measurement signals?
A series of Matlab measurements were made with both broadband and narrowband signals to generate spectrograms with the frequency lowering feature on and then off. Direct comparisons can then be made between the two resulting graphs by generating a new spectrogram which can illustrate the differences between the two. This methodology was applied to gain matched hearing aids from four manufacturers with frequency lowering that are commercially available today.

Poster #74 – AMP15

Sensitivity to Dynamic Range Compression in Listeners with Impaired Hearing

Andrew Sabin, PhD; Femi Nyatepe-coo, Northwestern University, Evanston, IL
Frederick Gallun, PhD, VA Medical Center, Portland, OR
Pamela Souza, PhD, Northwestern University, Evanston, IL

Dynamic range compression is a signal processing technique that is widely used to reduce the difference in level between the most and least intense portions of a signal. Such compression is used in hearing aids to compensate for the reduction in audiometric dynamic range that is characteristic of sensorineural hearing loss. Compression distorts the temporal envelope of the input signal. In a previous investigation of listeners with normal hearing, we observed that, on the group level, sensitivity to these distortions is well predicted by the compression-induced distortion to the modulation spectrum, and that, on the individual level, sensitivity to compression is correlated to the listener's ability to discriminate the depth of sinusoidal amplitude modulation. Here we repeat this experiment in listeners with sensorineural hearing loss. Preliminary results suggest that the patterns of group- and individual-level performance are similar across the two groups. However, consistent with other reports, the listeners with hearing impairment show greater individual variability than those with normal hearing. This work could potentially be used to guide hearing aid fitting by identifying the compression parameter values that are perceptually distinct, and by identifying the listeners are sensitivity to signal processing that alters the temporal envelope. [Supported by NIDCD]

Poster #75 – AMP16 - **T35 Research Trainee Poster**

Differences in Sentence Recognition Between Default Telecoil and Programmed Telecoil

Erin Hawkins; Michael Valente, PhD; Kristi Oeding, AuD,
Washington University School of Medicine, St Louis, MO

Differences between the measured telecoil and microphone frequency response may explain why patients express difficulty using the telephone via the telecoil. The primary purpose of this study is to determine possible differences in sentence recognition using HINT sentences between a default telecoil-loop, default telecoil-phone, and a programmed telecoil. The frequency response of the programmed telecoil will match the microphone response previously programmed to NAL-NL1. The HINT sentences will be transmitted to the telecoil using a NoizFree telecoil earphone. The null hypothesis suggests there will be no statistically significant differences in sentence recognition between the default telecoil-loop, default telecoil-phone, and programmed telecoil. If the programmed telecoil provides improved performance than the two default telecoil settings, then programming the telecoil to match the programmed microphone response should be considered as part of Best Practice. Results may provide insight into the importance of programing the telecoil to patients hearing loss and not accepting manufacturer's first fit for the telecoil response.

Poster #76 – AMP17 - **T35 Research Trainee Poster**

Spatialization with Severe-Profound Hearing Loss: One or Two Hearing Aids?

James Shehorn, University of Arizona, Tucson, AZ
Todd Ricketts, PhD; Erin Picou, PhD, Vanderbilt University, Nashville, TN

The purpose of this study was to continue to develop and evaluate a test battery that is sensitive to unilateral vs. bilateral amplification. The test measures that are most sensitive to bilateral advantage are then compared to various typical clinical measures in an attempt to determine which listeners most benefit from wearing two hearing aids instead of just one, for which clinicians currently lack an evidence-base. While previous studies have revealed only limited benefit for spatial hearing benefit (Ricketts, 2000; Kobler and Rosenhall, 2002; Boymans, 2003; Walden and Walden, 2005), it is proposed that in a more realistically complex listening environment (i.e. multi-talker intelligible babble, reverberation, and visual cues) larger effects may be observed. Several complex listening environment tests were previously developed, and in the current study these measures were evaluated in individuals with severe-profound hearing loss. Preliminary data have revealed large bilateral advantages and large individual differences within this group, particularly for reaction time and accuracy when identifying a sources location, and speech recognition in a complex, reverberant listening environment. Subjective measures also revealed consistent advantages for bilateral over unilateral amplification in these listeners. [Supported by NIH-NIDCD T35DC008763]

Poster #77 – AMP18

Pole-zero Fitting of Hearing-Aid Receiver System's Transfer Function

Noori Kim, MS; Jont Allen, PhD
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The oldest magnetic earphone, the Balanced Armature Receiver (BAR), is the most widely used receiver in modern hearing-aid instruments, where the efficiency of the power (battery life) and the size of the device, as well as the larger frequency bandwidth, are critical parameters. Since these miniature loudspeakers remain one of the most expensive components of hearing aids, a detailed study of them is critical to understanding the hearing-aid system. This study was motivated by Hunt parameter calibration of a widely-used commercial hearing-aid receiver ED series, manufactured by Knowles Electronics, Inc. Hunt's two-port parameters (the electrical impedance Ze(s), acoustic impedance Za(s), and electro-acoustic transduction coefficient Ta(s)) are calculated using ABCD and impedance matrix methods from electrical input impedance measurements Zin(s), which vary with given acoustical loads (Hunt, 1954; Van Valkenburg, 1964; Weece and Allen, 2010). The transfer function of BAR system, the pressure over the voltage, is calculated from Hunt's parameters, and we further investigate the system by polezero fitting (Gustavsen and Semlyen, 1999). By decomposing the transfer function into all-pass and minimum-phase parts, the delay of this system is estimated via group delay of the all-pass filter. It shows that the BAR system is a linear, time-invariant, stable, and causal system. Ultimately, this work will deliver an innate understanding of the hearing-aid receiver's system.

PEDIATRIC AUDIOLOGY/OTOLOGY

Poster #78 – PED01

Objective Threshold Determination in Children with Auditory Neuropathy Spectrum Disorder

Danielle Verrilli, BA; Shuman He, PhD; Patricia Roush, AuD; John H. Grose, PhD; Craig A. Buchman, MD, University of North Carolina at Chapel Hill, Chapel Hill, NC

PURPOSE: This study investigated the feasibility of using the onset cortical auditory evoked potential (CAEP) to objectively estimate hearing thresholds in children with Auditory Neuropathy Spectrum Disorder (ANSD).
METHODS: Five children with ANSD and various degrees of hearing loss participated in this study. None had anatomic malformations or a mixed hearing loss. Hearing thresholds at octave frequencies between 250 and 4000 Hz were determined using standard behavioral audiometry and CAEP measures. Electroencephalographic (EEG) activity was recorded differentially between surface recording electrodes placed at the high forehead (Fz) and the contralateral mastoid. An electrode placed on the low forehead (Fpz) served as the ground. For each patient, a minimum of two averages of 100 artifact-free sweeps were recorded for each condition. Identification of waveforms was based on peak latency, waveform morphology, and neural response replication.
RESULTS: CAEP thresholds were higher than the corresponding behavioral thresholds for all frequencies. For frequencies from 500 to 2000 Hz, the difference was 5-10 dB. The difference at 4000 Hz was approximately 10-15 dB. At 250 Hz, the difference was 20-25 dB.
CONCLUSIONS: Preliminary results suggest that estimation of behavioral hearing thresholds may be possible using the onset CAEP in children with ANSD.
[Acknowledgement: This work was supported in part by grants from NIH/NIDCD (1R21 DC011383) and The Deafness Research Foundation.]

Poster #79 – PED02

An Examination of the Validity and Reliability of the Infant-Toddler Meaningful Auditory Integration Scales

Brittan Barker, PhD; Neila Donovan, PhD; Anne Schubert; Elizabeth Walker, PhD,
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BACKGROUND & SIGNIFICANCE: The Infant-Toddler Meaningful Auditory Integration Scales (IT-MAIS; Zimmerman-Phillips, et al., 2000) is used to assess the development of pediatric cochlear-implant (CI) users' auditory integration skills. However, the IT-MAIS was not developed using rigorous psychometric analysis. We argue it is essential to have a valid assessment of auditory integration abilities to successfully identify pediatric CI candidates and monitor their post-CI auditory growth. This study assessed the validity and reliability of the IT-MAIS (at the item-level and overall) using the one-parameter Item Response Theory model Rasch analysis.
METHODS: To analyze content validity, 4 graduate students rank ordered the IT-MAIS based on the predicted order of each assessed behavior's emergence. To assess content, face, and construct validity we analyzed longitudinal IT-MAIS data using Rasch analysis. The analysis was performed using scores from 23 CI users ages 0-3 years old. Pre- and post-stimulation data were assessed.
RESULTS: Our analyses suggested that the item-level psychometric properties of the IT-MAIS are not strong and do not conform to a theoretically sound developmental process for auditory integration.
CONCLUSIONS: We conclude with suggestions to improve the IT-MAIS' validity as a tool for assessing auditory integration skills in profoundly deaf children ages 0-3 years old.

Poster #80 – PED03 - **T35 Research Trainee Poster**

Gesture Development in Toddlers with Hearing Loss.

Rachel Van Oosbree, BS, University of Arizona, Tucson, AZ
Sophie Ambrose, PhD; Mary Pat Moeller, PhD, Boys Town National Research Hospital, Omaha, NE

Objective: This longitudinal, descriptive study examined multimodal communication (gesture, sign, and speech) for toddlers with hearing loss (HL) and their mothers.
Method: Participants were six mother-child dyads in which the child had moderate to profound HL. Language analysis software was used to transcribe and analyze gesture, sign, and speech use in mother-child interactions at four time points (corresponding to child ages of 13.5, 18, 22.5, and 27 months).
Results: Initially, as a group, children primarily utilized gesture for communication. However, by 22.5 months, spoken communication was dominant. This shift was slightly delayed in comparison to a similar shift reported for typically-developing children. Mothers demonstrated relatively stable use of gesture and consistently high rates of spoken language. Sign use was variable, with the majority of mothers modifying their sign use over time in response to changes in children's spoken language abilities.
Conclusions: Longitudinal data suggest that the gesture use of children with HL mirrors that of typically-developing children, although delays in spoken language development may result in a prolonged reliance on gesture use. Mothers appeared to be strategic in their use of multimodal communication, which may have served to support children's spoken language development.

Poster #81 – PED04

Timeliness of Service Provision for Late-Identified Children with Hearing Loss

Elizabeth Walker, PhD, University of Iowa, Iowa City, IA
Meredith Spratford, AuD, Boys Town National Research Hospital, Omaha, NE
Lenore Holt, PhD; Jacob Oleson, PhD, University of Iowa, Iowa City, IA
Melody Harrison, PhD, University of North Carolina, Chapel Hill, NC

The Outcomes of Children with Hearing Loss (OCHL) study is a longitudinal, NIH-funded, multi-center study that explores outcomes of children with mild to severe hearing loss (HL). In this poster, we describe the effect of family- and child-specific variables on timeliness of follow-up for 74 OCHL participants who were not identified with HL at birth. Multiple regression models were used to investigate the relationships among independent predictor variables (sex, test site, degree of HL, maternal education level, and family history of HL) and dependent variables of timing of service provision. Among the independent variables, only degree of HL was statistically significant at the .05 level in predicting ages at first diagnostic evaluation, confirmation of HL and hearing aid fit. Children with more severe HL received audiologic services earlier than children with milder HL. Only sex was statistically significant in predicting the length of delay between confirmation of HL and entry into early intervention, with females demonstrating a shorter delay in the process. No variables were significantly related to the age at entry into early intervention or delays between confirmation of HL and hearing aid fitting. Reasons for delays based on parent report are also described. Supported by NIDCD R01 DC009560.

Poster #82 – PED05 - **Mentored Student Research Poster Award**
Negative Effects of Noise on Auditory Working Memory in Children
Homira Osman (Mentored Student); Jessica R. Sullivan, PhD,
University of Washington, Seattle, WA

The purpose of this study was to evaluate the effects of noise on working memory performance of children with normal hearing. Two primary questions were addressed: (1) whether children demonstrate poorer auditory working memory performance in degraded signal-to-noise ratios (SNR) than in quiet, and (2) whether the amount of cognitive demand of the task contributes to differences in performance in noise. Twenty children with normal hearing, ages 8 to 10, were assessed using three subtests of the Working Memory Test Battery for Children in quiet and in the presence of four-talker babble noise at 0 dB and -5 dB SNR. The tasks were forward digital recall, backward digital recall, and listening span task. Each sub-test was administered using a span procedure at 65 dB SPL across listening conditions. We found working memory performance decreased as SNR became poorer and with greater cognitive demand of the task. The results of a two-factor ANOVA demonstrated significant main effects for listening conditions and task. Specifically, tasks that involved both storage and processing were negatively impacted by the addition of noise. These results imply that noise negatively influences auditory working memory and may impact speech understanding in noise in children.

PHYSIOLOGIC RESPONSES: MIDDLE EAR AND COCHLEA

Poster #83 – PHYS01 - **T35 Research Trainee Poster**
Test-Retest Reliability of Auditory Physiologic Responses over Various Time Intervals
Kristen D'Onofrio, MA; Linda J. Hood, PhD,
Vanderbilt University, Nashville, TN

The purpose of this study was to examine test-retest differences within and between test sessions for physiologic responses from the middle ear, cochlea, and brainstem. Wideband acoustic transfer functions (WATF), transient-evoked otoacoustic emissions (TEOAE), and auditory brainstem responses (ABR) were collected from ten normal-hearing adults and five infants in the NICU. Within a single test

session, repeated measures were made with the probe left in place, followed by removal and re-insertion of the probe. This same procedure was repeated 2-3 days following the first session, and again 1 week later. Test-retest differences were calculated across one-third octave bands for the WATF measures, and half-octave bands for the TEOAEs. ABR latency and amplitude were calculated for recordings obtained at 70 and 40 dB nHL. In adults, test-retest differences were smallest when the probe remained in place and greatest when tested across days. The infant data are considered preliminary and analysis was limited to higher frequencies for the WATF and TEOAE data. Test-retest WATF variation followed a pattern consistent with adults, while TEOAE differences were similar across test conditions. These data will be valuable in our future studies utilizing these physiologic measures over time in infants and adults. [Supported by NIH-NIDCD T35DC008763]

Poster #84 – PHYS02

Psychophysical and Otoacoustic Emission Estimates of Cochlear Compression

Travis Moore, AuD; Benjamin Hornsby, PhD; Linda Hood, PhD,
Vanderbilt University, Nashville, TN

Hearing impairment due to loss of cochlear nonlinearity results in elevated hearing thresholds, loudness recruitment, poorer frequency selectivity and reduced temporal resolution. These significant effects on the perception of sound suggest a utility in estimating cochlear compression in the individual. However, attempts at quantifying cochlear compression have proven time consuming, and variable across methods. The objective of this study was to examine the relationship between behavioral and physiological compression estimates derived from a novel method of collecting and analyzing DPOAEs [Long et al., J. Acoust. Soc. Am. 124, 1613-1626 (2008)]. This new technique allows for a shorter testing time and separation of the traditional DPOAE response into its two presumed constituent components (generator and reflection). Compression estimates from the traditional DPOAE response and each separated component were compared to compression estimates derived from a growth of forward masking (GOM) paradigm. Initial descriptive results suggest that DPOAE and GOM estimates of cochlear compression are very similar near 4 kHz, with estimates from the generator component being the most strongly correlated to GOM estimates. Compression estimates derived from the traditional DPOAE response varied depending on position of the test stimulus in DPOAE fine structure, while those of the generator component did not.

Poster #85 – PHYS03

Amplitude-Modulated Stimulus-Frequency Otoacoustic Emissions in Normal and Impaired Ears

Greta Stamper, AuD; Nikki Go, MA; Lindsey Pacey, Resident; Jamie Broadbent; Tiffany Johnson, PhD,
University of Kansas Medical Center, Kansas City, KS

Few data exist that examine stimulus-frequency otoacoustic emissions (SFOAEs) in hearing-impaired ears. The amplitude-modulated (AM) SFOAE technique (Neely et al., 2005) is an efficient method for recording SFOAEs that incorporates the use of an AM suppressor tone. Previous data utilizing this technique have described the influence of stimulus parameters on SFOAE level in normal ears (Johnson & Maack, 2010). Data from the current study expands the previous work to include comparisons between AM-SFOAE response distributions in both normal and impaired ears. Data were collected from normal and impaired ears where behavioral thresholds were assessed using the standard clinical approach and a 2-interval forced choice (2IFC) task. In these subjects, AM-SFOAEs were recorded with probe levels of 35, 45, and 55 dB SPL at probe frequencies of 1, 2 and 4 kHz, using the stimulus

parameters described in Johnson and Maack (2010). Results from normal and impaired ears will be presented relative to the amount of overlap in the response distributions, where less overlap is desired when making distinctions between normal and impaired responses. The influence of behavioral threshold assessment technique (standard clinical vs. 2IFC) on the amount of overlap will be discussed. [Work supported by the NIH-NIDCD R03 DC011367.]

Poster #86 – PHYS04

Clinically Applicable Method of Calibration for Measuring High-Frequency DPOAE Repeatability

Shelli Newman, PhD; Talya Jacob; Michelle Louie; Laura Dreisbach, PhD,
San Diego State University, San Diego, CA

Alternate calibration methods have been proposed to combat the issue of standing waves in the ear canal when recording distortion-product otoacoustic emissions (DPOAEs). An advantage of using alternate calibration methods is increased DPOAE repeatability, critical in monitoring programs. Unfortunately, proposed alternate calibration methods have not been implemented widely in clinics, possibly due to equipment limitations. In this study, we explored DPOAE repeatability over four trials using a consistent probe placement in the ear canal and an alternate calibration method. To determine DPOAE repeatability, DPOAEs were measured from 8-16 kHz with a f2/f1 of 1.22 and L1/L2 equal to 65/50 dB SPL. Additionally, input/output functions were collected at 8, 10, and 12 kHz where L2 was 50 dB SPL and L1 was varied from 10-70 dB SPL in order to determine DPOAE thresholds. The alternate calibration method typically resulted in greater DPOAE levels compared to using a consistent probe placement in the ear canal, but both methods yielded repeatable measures across trials. Additionally, differences in DPOAE levels and thresholds between trials were similar between the two methods and smaller than with traditional calibration methods. Thus, ensuring a consistent probe placement in the ear canal can improve DPOAE repeatability in clinics currently.

Poster #87 – PHYS05

Evaluation of Test-Retest Variability of Extended-Frequency Otoacoustic Emissions in Children

Chris Sanford, PhD, Idaho State University, Pocatello, ID
Shawn Goodman, PhD, University of Iowa, Iowa City, IA
Sarah Weber; Suman Barua, MS; Jeff Brockett, Idaho State University, Pocatello, ID

High-frequency otoacoustic emissions may be useful for monitoring ototoxicity, especially in children, who typically have good high-frequency hearing . However, it is unclear which measurement paradigm is the most stable across repeated measurements. The present study assessed the limits of normal variability of high-frequency (2-16 kHz) distortion product and transient evoked otoacoustic emissions (DPOAE/TEOAE) in children with normal hearing. DPOAE/TEOAE recordings were obtained approximately once a week for six consecutive weeks from 40 children (5-17 years) with normal hearing. Repeated DPOAE/TEOAE measures were also obtained within each visit. Two in-situ calibration options were evaluated for each DPOAE/TEOAE recording: sound pressure level and forward pressure level. DPOAE/TEOAE magnitude was evaluated in terms of dB change relative to the data obtained during the first visit. Prediction intervals for change in DPOAE/TEOAE magnitude were computed for the five subsequent visits. Repeated DPOAE/TEOAE measures taken during each visit were used to assess variability due to probe placement versus variability due to DPOAE/TEOAE magnitude changes over time. Prediction intervals are presented, with potential use for determining when a statistically

significant shift in DPOAE/TEOAE responses has occurred for individuals exposed to ototoxic medications. The stability of different in-situ calibration routines is also discussed.

Poster #88 – PHYS06 - **Mentored Student Research Poster Award**
A Test of Otoacoustic Emission Sensitivity to Acoustic Overstimulation
Karolina Charaziak, MS (Mentored Student); Jonathan Siegel, PhD,
Northwestern University, Evanston, IL

When acoustically stimulated the cochlea emits sounds back to the ear canal (otoacoustic emissions, OAEs). As OAEs require functional hair cells, changes in OAEs can be indicative of changes in hair cell function, e.g., following the overstimulation to sound. According to the commonly accepted model of OAE generation, emissions evoked with either a transient stimulus (Transient Evoked OAE) or a pure tone (Stimulus-Frequency OAE) should be more sensitive to subtle changes in hair cell function than emissions evoked with pairs of tones (Distortion Product OAEs). In this study we evaluate the effectiveness of these different measures of OAEs in estimating changes in neural thresholds (compound action potential, CAP) resulting from exposure to an intense 3 kHz tone. TEOAEs, SFOAEs and DPOAEs were measured in six chinchillas with low-level stimuli pre- and post-exposure. The levels of all types of emissions typically dropped for stimuli near 4 kHz, the frequency of greatest CAP shift, following the acoustic trauma. However, the SFOAE and TEOAE level shifts were always smaller and poorly correlated with the amount of shift observed for CAP. DPOAEs usually demonstrated a larger drop in level and often better mapped the CAP threshold shift than either TEOAEs or SFOAEs.

Poster #89 – PHYS07 - **Mentored Student Research Poster Award**
The Generation, Location and Mechanism of Early TEOAE Components
James Lewis, AuD (Mentored Student); Shawn Goodman, PhD,
University of Iowa, Iowa City, IA

Band-pass filtered, transient-evoked otoacoustic emissions (TEOAEs) exhibit two peaks in the time domain. The later peak is consistent with linear coherent reflection (LCR) from the traveling wave peak. This study investigated the generation mechanism and site of the earlier TEOAE peak. Intermodulation distortion (IMD) has been proposed as the generation mechanism for the early latency TEOAE peak. Two experiments were conducted to test the IMD hypothesis. Experiment 1 used transient stimuli with progressively narrower bandwidths to evoke OAEs. IMD predicts that as stimulus bandwidth decreases, the magnitude of the early latency peak also decreases. Experiment 2 used two-tone suppression to determine the generation site of the early TEOAE peak. IMD predicts a generation site at f2 for a 2f1-f2 distortion product. Results from Experiment 1 showed the magnitude of the early latency TEOAE peak to be relatively independent of stimulus bandwidth. Results from Experiment 2 suggested the generation site of the early TEOAE peak basal to the peak of the traveling wave, but too apical to be a 2f1-f2 distortion product. Results were inconsistent with the early peak being generated by IMD. An alternative theory is that the early peak is generated by reflections basal to the traveling wave peak.

Poster #90 – PHYS08 - **Mentored Student Research Poster Award**
Influence of Calibration on Distortion-Product Otoacoustic-Emission Variability Using High-Frequency Stimuli
Elizabeth Stewart (Mentored Student); Tiffany Johnson, PhD, Mark Chertoff, PhD,

University of Kansas Medical Center, Kansas City, KS

Previous research examining variability in distortion-product otoacoustic emission (DPOAE) level associated with changes in probe insertion depth found that forward pressure level (FPL) calibration yielded reduced within-subject variability when compared with SPL calibration (Scheperle et al., 2008). The objectives of the present study were (1) to determine if these previous findings could be replicated, and (2) to evaluate the effect of both calibration methods on DPOAEs recorded at higher frequencies than previously tested. As expected, when absolute differences in DPOAE level between deep and shallow insertions were compared, FPL calibration yielded significantly smaller changes in DPOAE level than SPL calibration for the frequencies tested by Scheperle et al. In contrast, FPL calibration did not reduce within-subject variability associated with changes in probe insertion for f2 > 8 kHz. An unexpected finding in the present study was that DPOAE levels recorded with a shallow insertion depth were typically larger than those obtained with a deep insertion depth. Possible mechanisms underlying this observation will be discussed. The data from the present study suggest that, with regard to DPOAE variability, there may be an advantage to using FPL calibration, but only for f2 ≤ 8 kHz. [Work supported by the NIH-NIDCD R03 DC011367.]

Poster #91 – PHYS09 - **T35 Research Trainee Poster**

Effect of Calibration Method on Distortion-Product Otoacoustic Emissions

Michal Reuven, BA, University of Maryland, College Park, MD
Stephen Neely, PhD; Judy Kopun; Daniel Rasetshwane, PhD,
Boys Town National Research Hospital, Omaha, NE
Jont Allen, PhD, University of Illinois, Urbana, IL
Hongyang Tan; Michael Gorga, PhD, Boys Town National Research Hospital, Omaha, NE

In the ear sound pressure level (SPL) calibrations, which are widely used when measuring distortion-product otoacoustic emissions (DPOAEs), are susceptible to standing waves created by the overlap of incident and reflected waves. It has been shown that forward pressure level (FPL) calibration minimizes standing-wave effects by isolating the forward-propagating component of the stimulus. Previous research that restricted DPOAE measurements to octave and interoctave frequencies failed to demonstrate more than a small difference in test performance and behavioral threshold prediction following SPL and FPL calibration (Burke et al., 2010; Rogers et al., 2010; Kirby et al., 2011). To optimize our chances of observing differences related to calibration, DPOAE I/O functions were obtained from 42 normal-hearing individuals and 93 individuals with hearing loss with f2 set to each subject's standing-wave frequency and to 4 kHz. DPOAE levels were larger following SPL calibration, compared to those measured following FPL calibration, which demonstrated the expected impact of standing waves. The best test performance was achieved at moderate stimulus levels for both calibration methods, with differences in test performance at low and high stimulus levels, and slightly better test performance following FPL calibration for clinically relevant conditions. Calibration method had no effect on threshold prediction.

Poster #92 – PHYS10

Cochlear Reflectance: Multivariate Test Performance and Threshold Prediction

Daniel Rasetshwane, PhD; Sara Fultz; Judy Kopun; Michael Gorga, PhD; Stephen Neely, PhD,
Boys Town National Research Hospital, Omaha, NE

Cochlear reflectance (CR) is defined as the cochlear contribution to ear-canal reflectance (ECR), and is equivalent to the transfer function between stimulus-frequency otoacoustic emissions (OAEs) and the forward-propagating component of pressure measured in the ear canal. An accompanying poster (Fultz et al., 2013) describes CR results following univariate analyses. Performance was disappointing, in that errors in diagnoses occurred. This study evaluates the clinical utility of CR test performance and threshold prediction using multivariate analyses. CR measurements were collected in 22 normal hearing (NH) and 38 hearing impaired (HI) subjects at levels of 10-70 dB in 10-dB steps using wide-band noise stimuli. NH subjects have higher CR magnitude (CRM) compared to HI subjects. Test performance, which was evaluated using multivariate analysis and clinical decision theory, showed perfect identification of ears (i.e., normal versus impaired ears). For multivariate threshold predictions, correlations between actual and predicted thresholds ranged from 0.80 to 0.96. The root-mean-square error between actual and predicted thresholds had a grand mean (across levels and frequency) of 7.32 dB. CR shows excellent potential for clinical utility, however, validation of the current multivariate analyses on an independent data set is required. [Work supported by the NIH]

Poster #93 – PHYS11

Reliability and Test Performance of Cochlear Reflectance Measurements

Sara Fultz; Daniel Rasetshwane, PhD; Stephen Neely, PhD; Judy Kopun, MA; Michael Gorga, PhD,
Boys Town National Research Hospital, Omaha, NE

The nonlinear contributions of ear canal reflectance are called cochlear reflectance (CR). The purpose of this study was to assess the reliability and test performance of CR measurements to determine if they are clinically useful. CR measurements were made in 22 normal-hearing (NH) and 38 hearing-impaired (HI) subjects. Data were collected at seven levels (10 - 70 dB SPL, 10-dB steps) using a wideband noise stimulus. CR measurement reliability was determined by comparing repeated measurements of CR magnitude (CRM). Within-subject correlations between the two best measurements ranged from 0.72 to 0.93, with the higher correlations at higher frequencies and levels. The mean absolute difference across level and frequency between all test runs for all subjects was 2.8 dB SPL, with few outliers. Test performance was evaluated using univariate analysis of area under the receiver-operating-characteristic (ROC) curve for the task of distinguishing between normal and impaired ears. Test performance was best for high frequencies (>1 kHz) and at mid-levels (levels of 30 -50 dB SPL) and was correlated with signal-to-noise ratio (SNR). ROC areas were smaller for CR compared to distortion-product otoacoustic emissions, but could potentially be increased by using longer averaging times to improve SNR.

Poster #94 – PHYS12

The Role of Olivocochlear Efferents in Auditory Perception

Aparna Rao, PhD; Tess Koerner; Brandon Madsen; Yang Zhang, PhD,
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This study investigated the role of olivocochlear efferents in listening in noise. Both ears of thirteen normal-hearing participants were tested. Behavioral tasks included hearing and speech perception in noise tests. Physiological tests consisted of Transient-Evoked OAE (TEOAE) inhibition and cortical Event-Related Potentials (ERPs). The Mismatch Negativity (MMN) and P300 responses were obtained in passive and active listening tasks respectively. Performance on the speech perception in noise test was comparable in the two ears and did not show changes in either ear in the presence of contralateral noise. The TEOAE data revealed a laterality effect, with greater inhibition of TEOAE in the right ear

compared with the left ear. A laterality effect was also found in the ERP results. In the left ear, presence of contralateral stimulation produced an enhancement in the MMN amplitude and no change in the P300 amplitude compared with the condition without contralateral stimulation. In the right ear, presence of contralateral stimulation did not cause changes in the MMN amplitude and led to a reduction in the P300 amplitude compared with the condition without contralateral stimulation. Results will be discussed by examining the links between cortical potentials, OAE inhibition, and speech perception in noise with contralateral stimulation.

Poster #95 – PHYS13 - **Mentored Student Research Poster Award**

Active Listening Modulates the MOC Reflex in Children

Spencer Smith (Mentored Student); Barbara Cone, PhD,
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Contralateral suppression of transient-evoked otoacoustic emissions (TEOAE) is observed by activating the medial olivocochlear bundle (MOCB) pathway of the auditory brainstem using low-level steady-state noise; this is known as the MOC reflex. Suppression is quantified as the difference in TEOAE amplitude and phase in the opposite (probe) ear in comparison to TEOAEs recorded in quiet. The MOC reflex is thought to be a mechanism involved in the perception of speech in noise (Guinan, 2006). This study investigated the extent to which the MOC reflex is modulated by 'top-down' cortico-fugal influences that are engaged during auditory attention. An innovative Auditory Stroop Task (AST) was used to engage active listening in 8-12 year old children while TEOAEs were recorded. Listeners were asked to identify either gender of the talker (easy condition) or the gender of the word (hard condition) as they listened to single-syllable words with specific gender meanings (e.g., king vs. queen, mom vs. dad) spoken by male or female voices. The words were presented at a 10 dB signal-to-noise ratio with the suppressor noise. Our data suggest that active listening modulates MOCB function in a graded manner based on task difficulty.

Poster #96 – PHYS14

Characterization of SOAEs in Children with High-Frequency DPOAEs

Talya Jacob, PhD; Shelli Newman, San Diego State University, San Diego, CA
Michelle Louie; Laura Dreisbach, PhD

The significance and usefulness of spontaneous otoacoustic emission (SOAE) measures are still being explored, but they are consistently observed in adults and children with normal hearing. The purpose of this study was to determine the SOAE characteristics of 42 children (age 3-6 and 10-12 years) with high-frequency (> 8 kHz) distortion product otoacoustic emissions (HF DPOAEs). Specifically, SOAEs were characterized by frequency, amplitude, age, gender, and number of SOAEs in each ear. Descriptive comparisons were made to published SOAE characteristic data in adults and children, as well as SOAE characteristics in adults with HF DPOAEs. Preliminary results revealed SOAEs observed at frequencies similar to those reported in the literature and higher than 10 kHz, a mean amplitude of 3.5 dB SPL (standard deviation: 7.8), an average of 3 SOAEs per subject, and an increased prevalence of SOAEs in the right ear. Few studies have identified SOAEs at frequencies above 10 kHz, which may be due to equipment limitations (Lees, 2008). These findings provide new insight into the SOAE characteristics in children who were required to have HF DPOAEs and elucidate the relationship between SOAEs and cochlear processes.

Poster #97 – PHYS15

Primary Sweep Rate and DPOAE Fine-Structure in Newborns and Adults

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DPOAE levels exhibit a rippled pattern across frequency, called fine-structure, when continuously-sweeping primaries are used. Two underlying cochlear mechanisms are responsible for this pattern, and can be extracted from the DPOAE fine-structure recordings. At slow sweep rates, the DPOAE fine-structure is independent of sweep direction (from low-to-high frequencies or from high-to-low frequencies). When primaries are swept faster than 2s/octave, there is a pattern of frequency shifts that depends on sweep direction. The pattern of shifts may depend on cochlear processing, allowing exploration of auditory maturation. The goal of this study was to evaluate whether DPOAE level fine-structure in newborns evoked with fast sweeps differs from that evoked by slow sweeps, and whether the DPOAE fine-structure frequency shifts for the two sweep directions are similar in newborns and adults. DPOAE fine structure was evoked using f2 primaries that swept from 1500 to 6000 Hz; f2/f1 =1.22. Both primaries were presented at 65 dB SPL. Test and re-test conditions were measured using sweep rates of 2s/octave and 1s/octave. Differences in DPOAE fine-structure between test and re-test conditions, as well as frequency shifts in DPOAE fine-structure evoked by the two stimulus rates will be discussed. (Research supported by the March of Dimes Foundation).

Poster #98 – PHYS16

Decreasing Environmental Noise in DPOAE Screenings Using a Noise Barrier

Cheri Taylor, BS; Janet Koehnke, PhD; Joan Besing, PhD; Maris Appelbaum, AuD,
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A secondary strategy for identifying hearing disorders is through the use of hearing screenings. When otoacoustic emission (OAE) screenings are completed in noisy environments, the results may indicate absent OAEs when they are, in fact, present. The purpose of this study was to determine whether screening distortion product otoacoustic emissions (DPOAE) inside a sound attenuating enclosure would produce a higher pass rate than DPOAEs screened outside of the enclosure. Testing took place in a Special Olympics Healthy Hearing (SOHH) environment. 81 subjects included both non-athletes (35) and athletes (46) ranging in age from 11-72 years old. On average, sound level meter measurements made during the screenings indicated the noise level inside the enclosure was approximately 6-8.5dB lower than outside the enclosure. Overall results revealed a significant improvement in the pass rate when subjects' DPOAEs were screened inside the noise-barrier enclosure. When the athletes and non-athletes' data were analyzed separately, the non-athletes data revealed significant improvement in the pass rate forsubjects tested inside the enclosure but the athletes' data did not reveal a significant difference. We plan to obtain more data at future Special Olympics events in order to determine whether this athlete/non-athlete difference is maintained.

Poster #99 – PHYS17

Exploring Inter-subject and Intra-subject Variability in Absorbance

Defne Abur; Susan Voss, PhD; Nicholas Horton, PhD,

Smith College, Northampton, MA

Repeated measurements of absorbance were made on eight subjects on a weekly basis for four to eight weeks. At each session, measurements were made at three locations: the standard insertion depth (foam plug being flush at the entrance to the ear canal) and plus and minus 3mm from the standard depth. Random effects regression models were used for the analysis to account for repeated measures within subjects. The mean absorbance for each position over all sessions was calculated for each subject and was found to depend on the location of the probe in the ear for low to mid-range frequencies. The standard deviation between subjects' mean absorbance after controlling for ear (left or right) and the standard deviation within individual subjects' mean absorbance were found to be of similar magnitude.

Poster #100 – PHYS18 - **Mentored Student Research Poster Award**

Pole-Zero Fitting of Middle-Ear Reflectance Data to Characterize Pathologies

Sarah Robinson (Mentored Student); Jont Allen, PhD,
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Wideband acoustic reflectance measurements have shown increasing utility for clinical assessment of the middle ear. Reflectance is measured at ambient pressure using a foam-tipped probe sealed in the ear canal, containing a microphone and loudspeaker (i.e. MEPA/HearID, Mimosa Acoustics). Reflectance is a complex quantity; its phase is highly affected, but its magnitude is relatively unaffected, by ear canal characteristics between the probe tip and eardrum. Many studies indicate that the magnitude reflectance shows systematic variations from normal in the presence of middle ear pathology, thus is a useful diagnostic supplement to audiometry. By considering the complex reflectance instead of its magnitude alone, we aim to improve its diagnostic utility. Fitting poles and zeros to complex reflectance data over 0.2 to 6 kHz, we achieve an accurate parameterization of the complex data (<3% average error with 12 poles and 12 zeros). A lossless delay, approximating the ear canal, is factored out of each reflectance fit. Considering otosclerosis and ossicular discontinuity data mined from previous studies, it was found that pole-zero locations systematically vary from normal in the presence of middle ear pathologies. Pole-zero fitting shows promise for automated, robust diagnosis of middle ear pathology via concise characterization of individual measurements.

Poster #101 – PHYS19

Different Patterns of Wideband Reflectance in Down Syndrome

Jordana Soares, AuD; Juliana Granja Orosas, AuD; Tathiana Silva Pichelli, AuD,
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Navid Shahnaz, PhD, University of British Columbia, Vancouver, British Columbia, Canada
Renata Carvallo, PhD, University of São Paolo, São Paulo, Brazil

Introduction: The wideband reflectance evaluates the transmission and reflection properties of the middle ear, in a wide range of frequencies. Objective: To determine if there are differences in the reflectance pattern between the Down syndrome compared to a control group. Methods: Thirty four subjects with a mean age of 8.25 years, pooled into five groups, four with Down syndrome, according to tympanometry results, matched to a control normal hearing group were evaluated. Impedance 226 Hz probe, transient otoacoustic emission, wideband reflectance between 200 and 6000 Hz, and pure tone audiometry were performed. Results: All groups showed different reflectance patterns. There was no

statistically significant difference (pvalue >0.05) between the control group and the group with Down syndrome with normal middle ear function, except at 2000 Hz. However, there was a statistically significant difference (pvalue <0.05) between the control group and Down syndrome groups with middle ear abnormalities, mostly between 630 and 1600 Hz. Discussion and Conclusion: The Down syndrome groups with middle ear abnormalities seem to reflect more sound energy between 630 and 1600 Hz, showing some impairment in the sound reception. The wideband reflectance could be useful for diagnosis of middle ear disorders in Down syndrome.

SPEECH PERCEPTION

Poster #102 – SP01

Environmental Sound Masking of Speech in Children and Young Adults

Sarah Poissant, PhD; Nathaniel Whitmal, III, PhD; Emily Sussman,
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When children's speech perception abilities in noise are assessed, masking signals usually include speech noise and sometimes multi-talker babble. Throughout the course of a typical day, however, children listen in the presence of many other environmental sounds that might interfere with speech understanding. The purpose of this investigation is to determine the differential impact of environmental sounds on speech perception in children and adults. Subjects are children ranging in age from 5-10 years and young adults, all with normal hearing. The temporal characteristics of the environmental sounds include both interrupted and continuous sounds, with modulation spectrums that overlap those of speech. Additional maskers include babble, speech spectrum noise matched to the target sentences, and the same speech spectrum noise modulated by the envelopes of the environmental sounds. Speech reception thresholds are obtained using methods described by Tillman and Olsen (1973) for conditions in which the target and masker are co-located and also spatially separated. For data collected to date, it appears that environmental sounds have a greater negative impact on children than adults and that, in some cases, children are less able than adults to take advantage of any temporal dips that may be available in the masker.

Poster #103 – SP02 - **Mentored Student Research Poster Award**

Energetic and Informational Masking of Speech for Spanish/English Bilingual Children

Bianca Gomez, BA (Mentored Student); Lauren Calandruccio, PhD; Emily Buss, PhD; Lori Leibold, PhD,
University of North Carolina, Chapel Hill, NC

Understanding speech in noise is more difficult for children than for adults, but child-adult differences in auditory masking are larger when the competing background is speech (e.g., Hall et al., 2002). This is problematic for school-aged children, as most of their learning happens in complex acoustic environments. Given children's increased susceptibility to masking and the growing number of bilingual households in the US (US Census Bureau, 2009), it is becoming increasingly important that we understand how bilingual children are able to perceive speech in noise. The goal of this project is to assess the speech recognition abilities of Spanish/English bilingual children in both of their languages in the presence of competing noise or two-talker maskers. To this end, we have developed a tool to evaluate masked English and Spanish word identification using an adaptive four-alternative, forced choice response paradigm. Thirty bisyllabic English and Spanish words with similar phonetic inventories,

word frequency, and lexical neighborhoods were chosen as targets. Spanish/English bilingual adult females provided speech recordings in both languages; one produced the target words, and two others produced connected discourse used to generate the two-talker maskers. The development of this tool and preliminary data from bilingual Spanish/English children will be presented.

Poster #104 – SP03 - **Mentored Student Research Poster Award**
Four-year-olds Benefit from Integration of Auditory and Visual Speech Cues
Kaylah Lalonde, BA (Mentored Student); Rachael Frush Holt PhD,
Indiana University, Bloomington, IN

Although infants sense a link between auditory and visual speech signals, it is unclear whether preschoolers can use visual speech to aid perception. For example, young children sometimes fail to demonstrate audiovisual benefit during speech perception tasks. This study aimed to establish whether 4-year-old children integrate auditory and visual speech cues. Twelve adults and twelve children completed three audiovisual integration tasks that require varying levels of perceptual processing: matching auditory speech signals (/ba/ or /bu/) to corresponding visual articulations; discriminating visually-salient (/ba/ vs. /ga/) and less visually-salient (/ba/ vs. /ma/) speech contrasts in noise, in both auditory-only and audiovisual conditions; and identifying auditory-only and audiovisual words in noise. Both groups demonstrated audiovisual integration across all tasks. Children and adults showed greater audiovisual benefit in discriminating the visually-salient speech contrast than the less visually-salient contrast. In fact, children only showed benefit for the visually-salient contrast. Additionally, analysis of consonant substitution errors in the identification task revealed that the addition of visual information led to a significantly smaller proportion of visually distinct substitution errors in children (15.54%) and adults (42.26%). These results demonstrate that preschoolers can utilize visual speech cues at multiple levels of perceptual processing when tested with developmentally appropriate procedures.

Poster #105 – SP04
Connections Among Auditory Thresholds, Cognitive Abilities, and Self-Perceived Hearing
Karen S. Helfer, PhD; Sarah Laszok,
University of Massachusetts, Amherst, MA

A growing body of evidence supports the idea that cognitive abilities play an important role in the problems experienced by listeners (especially older listeners) in complex listening environments. However, little empirical data is available to identify how these factors influence self-perceived hearing ability. In this study, we measured hearing thresholds and cognitive abilities (working memory, processing speed, executive function, inhibition) along with self-perceived hearing handicap (via the HHIE-S: Weinstein et al., 1986) and self-perceived hearing performance (as measured by selected items from the Spatial and Speech Qualities Questionnaire: Gatehouse and Noble, 2004). Participants were middle-aged and older adults with hearing sensitivity that ranged from normal to a moderate hearing loss. This poster will detail connections among hearing thresholds, cognitive abilities, and self-perceived hearing handicap/auditory performance. [Work supported by NIH DC012057].

Poster #106 – SP05 - **Mentored Student Research Poster Award**
Comparing Working Memory in Babble in Young and Middle-Aged Adults
Michelle Neidleman, BA (Mentored Student); Ilse Wambacq, PhD; Joan Besing, PhD; Jaclyn Spitzer, PhD,

Montclair State University, Ringwood, NJ

Numerous working memory studies have shown that older adults perform more poorly than young adults and that background noise negatively affects working memory. Hearing status may be a confounding factor in the older individuals. Therefore, it would be beneficial to investigate working memory functions in adverse listening conditions early in the aging process (i.e., middle-age), when hearing functions are relatively unaffected. The focus of this study was to determine the influence of babble on a serial position working memory task in young adults and middle-aged adults with normal hearing. Middle-aged adults performed worse than young adults for position one in babble, but not in quiet. The young adults performed significantly better in babble than in quiet for position one, but the middle-aged adults did not. For serial positions two and three, the middle-aged adults performed more poorly than the young adults irrespective of listening condition. No age differences or effects of listening condition were found for the final two positions. The results indicate that both age groups have trouble recalling earlier pieces of information in quiet and in babble. However, middle-aged adults exhibit significantly greater difficulty, which suggests that cognitive declines in memory begin to occur in middle age.

Poster #107 – SP06

Text as a Supplement to Speech Understanding in Noise

Vidya Krull, PhD; Larry Humes, PhD,
Indiana University, Bloomington, IN

Recent advances in hearing technology have not significantly improved speech understanding in noisy backgrounds. This study examined the feasibility of using visual text, similar to that provided by closed-captioning, to supplement the understanding of degraded speech in young and older adults with normal hearing and hearing loss. Perceptual measures consisted of sentence recognition in three auditory-only, three text-only, and four combined conditions. Audiovisual benefit was calculated as the improvement in the combined conditions relative to the text- and auditory- only conditions. Cognitive measures included tests of working memory capacity, processing speed, inhibition, and the ability to form wholes from parts. Preliminary findings show significant audiovisual benefit for all three groups in three of the four combined conditions. Group differences were noted only for one of the ten perceptual measures. Older adults performed significantly poorer on measures of working memory, processing speed, and inhibition. Also, cognitive measures of inhibition and processing efficiency correlated with some measures of audiovisual benefit in young and older adults with normal hearing. Together, these results suggest that visual text may be used successfully to supplement speech understanding in noise in both young and older adults. However, the extent of benefit may depend on cognitive abilities.

Poster #108 – SP07

Comparison of Adaptive Versions of the CCT and the NST

Karrie Recker, AuD; Jumana Harianawala, AuD,
Starkey Hearing Technologies, Eden Prairie, MN

Speech-in-noise tests are often used to determine which of two hearing-aid technologies provides a better outcome for hearing-impaired listeners. One challenge that individuals performing this testing face, when deciding which test to use, is that most speech-in-noise tests with high-frequency-emphasis material were developed to be performed at a fixed presentation level. Selecting a single level that is

appropriate for all participants is challenging because there is likely a range in participants' performance; and choosing a single level means that some participants may perform at a floor or ceiling level for some of the test conditions. This is undesirable because it limits our ability to demonstrate improvements in speech recognition that are associated with different technologies.
In order to work around this challenge, we modified two tests - the California Consonant Test (CCT) and the Nonsense Syllable Test (NST) so that they could be performed in an adaptive manner. The goal of this study was to evaluate which of these two adaptive tests performed better in terms of repeatability, variability and test time.
Twelve normal-hearing individuals participated in this study. All participants were tested unaided and aided. Recommendations will be made regarding the future use of the adaptive versions of these tests.

Poster #109 – SP08 - **Mentored Student Research Poster Award**
The Effects of Temporal Offset Variations on Priming
Charlotte Morse-Fortier (Mentored Student); Amanda Griffin; Richard Freyman, PhD,
University of Massachusetts, Amherst, MA

Previous research has indicated that visually priming the content of an acoustic message can greatly enhance a listener's ability to understand degraded or masked speech. The current study expanded upon previous priming research by examining how temporal variations in the delivery of the prime relative to the auditory signal affect the accuracy of the listeners. Twenty normal-hearing young adults listened to nonsense sentences that were presented in the presence of a two-talker babble speech masker at a signal-to-noise ratio of -5 dB. While participants listened, they also read a sentence displayed on a computer screen. Their task was to decide whether the sentences they heard and read were the same or different. The timing of the visual prime onset varied, in 200-millisecond steps, from 1.8 seconds before to 2 seconds after the auditory stimulus onset. Results showed that a visual prime preceding the auditory prime improved subjects' accuracy relative to the unprimed conditions. Performance was best when the visual prime onset preceded the auditory stimulus onset by 1200 milliseconds, and decreased steadily as the prime appeared closer to, or followed, the sound. This could have therapeutic implications for the development of effective auditory training methods using priming.

Poster #110 – SP09
Auditory Segregation of Sequential and Concurrent Vowels
Keri Bennett, AuD, Michelle Molis, PhD; Marjorie Leek, PhD,
Portland VAMC-NCRAR/OHSU, Portland, OR

Speech in background noise presents listeners with a complex mixture of sounds that requires perceptual segregation of successive and overlapping speech streams. In this study, auditory segregation was assessed in listeners with normal hearing and in listeners with mild hearing loss for pairs of synthetic vowels presented either concurrently or in alternating sequences. Vowels within pairs differed on fundamental frequency, formant frequencies, or both. Percent correct identification was measured in the concurrent task, while degree of stream segregation was measured in the sequential task. No consistent group differences were found for either task, probably due to the mild nature of the hearing losses. However, there was a strong effect of formant similarity within vowel pairs, with poorest identification (concurrent task) and greatest segregation (sequential task) for vowels differing in both first and second formant frequency. Additionally, concurrent vowel identification improved slightly with increasing fundamental frequency difference within pairs, and only when there were formant

differences between vowels. For sequential vowels, increasing fundamental frequency difference increased segregation, particularly when members of the pair were the same vowel category. These findings are interpreted in terms of differential influences of pitch perception and spectral shape discrimination. [Work supported by NIDCD].

Poster #111 – SP10

Effects of Noise Type on Speech Recognition of Complex Sentences

Jessica Sullivan, PhD; Christi Miller, MS; Homira Osman; Cornetta Mosley; Rachel Ersoff,
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The aim of this study was to investigate potential effects of noise type on speech recognition of linguistically complex sentences. Participants were age-matched adults with and without hearing loss (N=12). Adults with normal hearing were administered a hearing test to verify hearing status and those with hearing loss were fit with Oticon Acto Pro bilaterally; accurate NAL-NL2 prescriptive gain was verified by Real-Ear Measures. The Perceptually Robust English Sentence Test Open-set (PRESTO) sentences were used in speech shaped noise and four-talker babble. PRESTO sentences vary in both length and syntactic structure, and keywords that fluctuate in their frequency. A quiet condition was administered for practice. The speech and noise were presented from 0 degrees azimuth at the following SNRs: -3,-6, 0, +3, +6, +9, +12 in each noise condition. In general, listeners with normal hearing performed significantly better than listeners with hearing loss across noise conditions and SNRs. Speech recognition performance in the speech-shaped noise was significantly better than the four-talker babble. All demonstrated poorer performance as the SNR decreased in both noise conditions. This study has clinical implications on the type of speech recognition testing that can be used to reflect real-world speech understanding in noise.

Poster #112 – SP11

The NIH Toolbox Measures of Hearing: Initial Norming Data

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The NIH Toolbox is a newly-developed assessment battery of motor, sensory, cognition, and emotional health designed to facilitate comparability across studies and to evolve a more comprehensive data base on these various components of functioning. Sensory measures include both newly-developed and existing tests used in audiology. We present data on the Words in Noise test (Toolbox version), the Toolbox Hearing Threshold Test, and the Hearing Handicap Inventory-screening version (HHI; adult and elderly versions). The Words in Noise test was adapted from the existing, widely-used, version. The Hearing Threshold Test was developed based on a double-modified Hughson-Westlake testing algorithm. The data presented are from a large-scale norming study that was conducted at multiple sites across the U.S.A., across various age bands, and in English and Spanish. All measures were administered by computer with the supervision of a layperson test administrator. Data across ages 6-85 show patterns of hearing ability that are consistent with other epidemiological studies. Moreover, we found expected patterns of correlations among the Toolbox measures as well as age. We conclude that

the Toolbox measures have acceptable levels of validity and can be useful, brief measures of hearing in future human studies.

Poster #113 – SP12

Impaired Speech Understanding and Unmasking with Whispered Speech

Dorea Ruggles, PhD; Peggy Nelson, PhD,
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Hearing impairment goes well beyond issues of audibility. In day-to-day communication, impoverishment of auditory signal features related to timing and bandwidth lead to special challenges in speech understanding, stream segregation, and signal unmasking. This study uses voiced and whispered speech in continuous and gated noise to investigate the role of fine timing pitch cues in speech understanding and unmasking for hearing impaired listeners. Normal hearing and impaired listeners heard grammatically correct nonsense sentences imbedded in spectrally-matched continuous or gated noise at signal to noise ratios (SNRs) ranging from -6 dB to +3 dB and reported three key words from each sentence. Despite half-gain amplification to compensate for loss of audibility, impaired listeners performed poorly when compared to normal hearing listeners, both in number of correctly reported words and in patterns of unmasking. Results suggest that pitch cues absent in the whispered speech provide especially important information for the impaired listeners, who likely rely on signal redundancies to improve understanding. Patterns of unmasking for the hearing impaired listeners suggest that gated noise, rather than providing glimpses of helpful signal information, may actually impose an extra confusion that increases the difficulty of the task.

Poster #114 – SP13

Investigating SRT 'Manipulators' for a Spatial Speech-in-Speech Test

Niels Søgaard Jensen, MSc; Søren Laugesen, PhD; Filip M. Rønne, PhD; Renskje K. Hietkamp, MSc; Julie Hefting Pedersen, MA,
Eriksholm Research Centre, Oticon A/S, Snekkersten, Denmark

Introduction: Measuring Speech-Reception Threshold (SRT) using adaptive procedures is popular, as testing yields results with desirable statistical properties. However, SRT measures have drawbacks related to the unbounded nature of the Signal-to-Noise Ratio (SNR) at which the SRT is achieved. A large spread in SRT may cause SNR confounds that lead to faulty conclusions, and very low SRTs may compromise the ecological validity of the result. If testing involves hearing aids, it means that the signal-processing algorithms in these devices may operate in conditions for which they were not intended. These issues may be addressed by introducing SRT manipulators in the test set-up, to control the SNR at which testing takes place for the individual listener. *Methods:* In a spatial speech-in-speech test, the effect on SRT of changing the spatial separation between target and maskers, changing the number of spatially separated maskers, changing the masker gender, and scoring in words versus sentences, was investigated using 20 hearing-aid users as listeners. *Results and conclusions:* Data collection is on-going. Preliminary data indicate substantial variations in the effects of the included SRT manipulators. The most efficient manipulators seem to be changing the spatial separation between target and maskers and scoring in words versus sentences.

Poster #115 – SP14

Relative importance of spectral and temporal resolution for fricative identification
Allison Witte; Joshua Alexander, PhD,
Purdue University, West Lafayette, IN

Previous studies have indicated the importance of high frequency cues for fricative identification. It is unknown how much temporal and spectral detail must be maintained in the high frequency signal for accurate fricative identification. Understanding the cues necessary for transmission of high-frequency speech information can help inform signal processing strategies intended to preserve or enhance them in hearing aids and cochlear implants. Results from multiple studies suggest that gross spectral and temporal information is sufficient for conveying these high frequency cues. This study aims to determine how the number of independent bands and the amount of temporal detail influences fricative identification in normal-hearing listeners. We hypothesize that vocoding the temporal envelope over a finite number of bands will lead to equivalent speech identification as the intact wideband signal. Fricatives spoken by 3 female talkers in an /iC/ context were vocoded using 1-4 channels per Equivalent Rectangular Band (3-12 channels total) with envelop cutoff frequencies ranging from 8 to 128 Hz. Results will help provide an understanding about the appropriate settings and hearing losses for current frequency lowering techniques as well as suggest ways in which future techniques might be designed to most effectively transmit wideband information over a narrower band.

Poster #116 – SP15
Modeling Outcomes with Frequency Lowering using Neural-Scaled Entropy
Varsha Hariram; Joshua Alexander, PhD,
Purdue University, West Lafayette, IN

Signal processing schemes such as nonlinear frequency compression (NFC) recode speech information by moving high-frequency information to lower frequency regions. Perceptual studies have shown that depending on the dominant speech sound, where compression occurs and the amount of compression can have a significant effect on perception. Very little is understood about how frequency-lowered information is coded by the auditory periphery or even what constitutes "information." We have developed a measure that is sensitive to information in the altered speech signal in an attempt to predict optimal frequency lowering settings for individual hearing losses. The Neural-Scaled Entropy (NSE) model examines the effects of frequency-lowered speech at the level of the inner hair cell synapse of the auditory nerve model [Zilany et al. 2009, J. Acoust. Soc. Am., 126, 2390-2412]. NSE quantifies the information available in speech by the degree to which the pattern of neural firing across frequency changes relative to its past history (entropy). Nonsense syllables with different NFC parameters were processed through a variety of simulated hearing losses using the auditory nerve model. Results are compared to perceptual data across the NFC parameters as well as across different vowel-defining parameters, consonant features, and talker gender. [Supported by NIDCD RC1DC010601]

Poster #117 – SP16 - **Mentored Student Research Poster Award**
Lexical Frequency and Performance on Consonant Nucleus Consonant Word Tests
Eugene Spindler, MS (Mentored Student); Richard Wright, PhD; Julie Arenberg Bierer, PhD,
University of Washington, Seattle, WA

This study reports on two analyses of the Consonant Nucleus Consonant (CNC) word lists often used to assess cochlear implant (CI) listeners. The first analysis examined the distribution of lexical frequency of

all 500 words in the 10 CNC lists, as described by the spoken word subset of the Corpus of Contemporary American English. Tests of central tendency indicated that the lists are highly skewed, with medians ranging from 6.7 (list 1) to 43.0 (list 7) token occurrences per million words. Performance tended to be poorer for words with lower lexical frequencies. In the second analysis, consonant and vowel error patterns were examined for 43 CI users. Consonants were analyzed for place, manner and voicing and vowel context. Vowel formant frequencies were also analyzed. Affricates were identified with the greatest accuracy in both initial and final positions. The vowels /i/, /ʊ/, and /ɔɪ/ were identified the most accurately. Consonant identification was more accurate in the presence of vowels with a low second formant (e.g. /ʊ/ and /ʌ/). These findings could contribute to the development of updated word lists and scoring criteria to inform the fitting of hearing aids and cochlear implants.

Poster #118 – SP17 - **T35 Research Trainee Poster**
Fatigue and Listening
Zoe Doss, BS; Benjamin Hornsby, PhD,
Vanderbilt University, Nashville, TN

Fatigue is a common though serious complaint of individuals with hearing loss. However, the underlying mechanisms responsible for these complaints are unclear. Subjective data suggests that additional cognitive demands associated with hearing loss may contribute. Persons with hearing loss must increase their cognitive effort to detect, decode, and process speech and other auditory signals. Subjective reports suggest this increased effort may lead to complaints of fatigue, although objective data supporting this hypothesis are lacking. This study examined the relationship between mental effort and fatigue in a group of young normal hearing listeners. Mental effort and fatigue were quantified subjectively using questionnaires and objectively by monitoring changes in cognitive processing speed and performance over time. Mental effort was manipulated by varying signal-to-noise ratio (SNR: -2, -4, and -6 dB) in a sustained speech task. Overall, results suggest that sustained speech processing demands led to fatigue in all conditions. As expected, subjective and objective measures suggest that mental effort increased as the test SNR worsened. However, in contrast to our hypothesis, fatigue was stable across SNRs, suggesting that factors other than increased cognitive processing demands (e.g., worsening SNR or the presence of HL) likely influence development of speech-processing related fatigue.
[Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35)]

VESTIBULAR

Poster #119 – VEST01 - **Mentored Student Research Poster Award**
Oculomotor Performance in Children with Autism
Christina DeFrancisci, AuD (Mentored Student); A. Sara Webb; Rebecca Groen; Avery Weiss; James Phillips, PhD,
University of Washington, Seattle, WA

Autism Spectrum Disorder is marked by impairments in social understanding, communication and repetitive behaviors. Impairments in neural networks including the cerebellum and brainstem have been reported but it is unclear how these are related to clinical profile. One way of assessing these neural structures is to evaluate oculomotor performance. If the neural pathways implicated in autism

overlap with those necessary for oculomotor performance, then the clinical results would reflect abnormal function. Oculomotor testing could be a viable assessment tool for understanding neural functioning in autism. This study examined oculomotor performance in children with high functioning autism (n=14) compared to age- and mental-age matched controls (n=28). Oculomotor abilities were assessed using gaze, saccade, sequential saccade, anti-saccade, smooth pursuit, optokinetic nystagmus, and vergence testing from the standard clinical vestibular battery. The autism group demonstrated increased horizontal saccade peak velocity, decreased horizontal optokinetic nystagmus slow phase velocity, and phase lead during smooth pursuit testing. Also, there was dramatically decreased performance in the autism group on the sequential saccade and anti-saccade tests, which engage structures other than the brainstem and cerebellum. These findings suggest that clinical measures of oculomotor performance differentiate autism from matched controls, and may provide insight into the pathophysiology of autism.

Poster #120 – VEST02

Vestibular Phenotype of Treatment Naïve Persons with NF2

Chris Zalewski, MA, National Institutes of Health (NIH), Bethesda, MD
Talah Wafa, AuD, Gallaudet University, Washington, DC
Michael Holliday, MD, Georgetown University, Washington, DC
Kelly King, PhD; Jeff Kim, MD; Ashok Asthagiri, MD; Carmen Brewer, PhD,
National Institutes of Health (NIH), Bethesda, MD

Neurofibromatosis type 2 (NF2) is an autosomal dominant condition resulting from mutation of merlin, a tumor suppressing-gene, and is characterized by bilateral vestibular schwannomas, other nervous system tumors, and subcapsular lens abnormalities. Common symptomatic manifestations include hearing loss, tinnitus and balance dysfunction. This prospective natural history study describes the prevalence and pattern of vestibular test findings in 47 persons, aged 8-69 years (mean age: 24.7 males, 32.6 females) with NF2 who were naïve to surgical, radiologic, and pharmacologic management of their vestibular schwannomas. We conducted a comprehensive vestibular test battery that included videonystagmography, computerized dynamic posturography, cervical vestibular evoked myogenic potentials, sinusoidal harmonic acceleration, and velocity step testing. Over 90% of our cohort had abnormal findings on one or more of these measures. Vestibular test results and patterns of abnormality will be described in relation to hearing status, tumor size, and other patient characteristics. In addition, we discuss challenges related to interpretation of test results in patients with bilateral vestibular disease, and the implications of vestibular testing on the management of persons with NF2.

Poster #121 – VEST03 - **Mentored Student Research Poster Award**

Effect of Galvanic Vestibular Stimulation on Soleus H-reflex

Apollonia Fox (Mentored Student); Koichi Kitano, PhD; David Koceja, PhD,
Indiana University, Bloomington, IN

Vestibular input, critical to the maintenance of balance, directly influences lower-limb motoneurons in the spinal cord via the vestibulospinal tract. Compensation of postural control following a vestibular loss is well documented; however, the neural basis for this compensation has yet to be fully elucidated. The purpose of the present study was to investigate the nature of the vestibular input to the spinal networks in the lower limbs. Six healthy subjects participated. Recruitment curves of the soleus H-reflex were obtained during quiet standing with and without galvanic vestibular stimulation (GVS). GVS consisted of

bilateral, bipolar stimulation of the mastoid (2 s duration, 2 mA, right side anode). Soleus H-reflex in the right leg was elicited by stimulating the tibial nerve at the popliteal fossa (1 ms duration). During GVS trials, GVS was delivered 100 ms prior to the H-reflex stimulation. Results indicate there were no significant differences in maximum H-reflex amplitudes (H/M ratio) between conditions, whereas the threshold for H-reflex was significantly reduced during GVS ($F(1,5) = 18.74$, $p < 0.05$). It is suggested that vestibular stimulation has a facilitatory effect on the soleus H-reflex through reducing presynaptic inhibition within the spinal cord.

Poster #122 – VEST04 - **T35 Research Trainee Poster**

The Effect of External Sound on Maintaining Balance

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Maintaining balance and reducing postural sway is critical for preventing falls, particularly among the elderly and those with vestibular impairments. Although enhancing haptic and visual cues has been shown to facilitate improvements in balance, the present study demonstrates how stationary auditory stimuli provide external reference cues to maintain balance in patients with sensory deficits. Center of pressure was measured for 12 subjects with hearing or vestibular deficits for balance conditions consisting of three 20-second trials each with either auditory, visual, or proprioceptive cues present. Sway was quantified as the 95% level on the cumulative distribution of pressure measurements. Sway with sound or vision added was linearly related to baseline sway. Sound reduced sway by 51% over the baseline condition. The improvement in sway with the addition of sound was linearly related to the improvement with addition of vision only; the addition of sound represented 55% of the addition of vision. This indicates that auditory input provides sensory information crucial for maintaining balance, particularly in low-light conditions and for patients with poor baseline balance performance. Optimized auditory input could be utilized to improve balance in those with sensory deficits via environmental cues or improvements in hearing aids or cochlear implants.